



THE SECOND NZAAR International Event Series on

NATURAL and BUILT ENVIRONMENT, CITIES, SUSTAINABILITY and ADVANCED ENGINEERING

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AN ASSESSMENT OF SITE LAYOUT PRACTICES OF CONSTRUCTION PROJECTS IN NIGERIA

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Abstract

Site layout has been identified an integral segment in the design and construction process, however their practices has been an issue in the Nigerian construction industry, especially among small and medium sized firms. Therefore, the research seeks to assess the site layout practices of construction project in Abuja, Nigeria with a view to improve productivity on construction projects. The research reviewed literatures on site layout practices and a survey made questionnaire was designed for the respondents, to determine their level of participation in site layout and the practises involved. The respondent of the questionnaires are construction professionals functioning at managerial level. The sample size for the research was calculated and a respondent of seventy one (71) was determined. Data was analysed using statistical tools such as mean, percentage and relative importance index and the information was presented in charts and figures. From the research finding, 'preparing site layout design before the commencement of site work' ranked first with (RII) value of 0.785, which is very significant. The research concluded that the major site layout practice is the preparation of site layout design before the commencement of site work. It recommends that further studies should focus on the design considerations and processes involved in the implementation of site layout plan in construction projects.

Keywords: Site Layout, Facilities, Management Practices, Construction Projects, Nigeria

1. Introduction

According to [1], the construction industry which is one of the most important sector of most national economy run into trouble majorly because of managerial factors rather than technical problems. The site-based management can make significant improvements in the cost and time savings during the construction process without involving a mass of additional work. The role of site managers is to control and maintain work performance and then taking actions to rectify situations where performance is unsatisfactory. Safety and accessibility should be given more consideration in site planning and also the designing of path for movement of transport rather than to limit the consideration only to distance and cost [2].

Among the important tasks of site management is the site layout planning. Extensive time loss and cost overruns could result in large projects, where the number of

manpower, subcontractors, and equipment involved are high, if there is no effective and systematic approach to site planning. A detailed planning of the site layout and location of temporary facilities can enable the management to make considerable improvement by minimizing travel time, waiting time, and increasing workers morale by showing better and safer work environment [3]. Construction site layout planning has been recognised as a critical step in construction planning, the basic function of the process is to find the most suitable arrangement for the positioning of the temporary facilities. Temporary facilities have to be placed right from the beginning of the project construction to the completion [4]. Due to the importance of site layout practice of construction project, this research will give emphasis on site layout practices of construction projects.

Site managers mostly abandon site layout design right from the inception of the

construction project thinking that it will be done as the construction project progresses. It is important to realize that the site planning will be the conditions that site personnel will live with for the total duration of the construction period. Thus, careful pre-planning is imperative. Also, since the labour cost on a large project constitutes approximately 50 to 60 percent of the total project cost, significant saving can be made if the labour force moves freely and quickly within the site. According to the Construction Industry Institute of Geneva, this reported in its "Constructability Concepts File" that temporary facilities are important elements that can either enhance or adversely affect construction productivity [5].

Construction project site layout involves the identification, sizing, and placing of the temporary facilities (TFs) at the required positions within the boundaries of the construction project site. These temporary facilities may range from simple lay-down areas to warehouses, fabrication shops, maintenance shops, batch plant, and residence facilities. Required temporary facilities and their areas are depending in many factors including project type, scale, design, location, and organization of construction work [6].

Site layout planning, in general, can be viewed as a complex problem that has many effects on construction project productivity, ranging from the site layout of small construction project to the site layout of large construction project. This problem has to be extensively addressed with respect to this research.

Efficient layout planning of a construction site is fundamental to any successful project. This usually consists of identifying the temporary facilities needed to support construction operation determining their size and shape and positioning them in the unoccupied areas within the site boundaries [7]. Examples of these temporary facilities

include offices and tool trailers, parking lots, warehouse, batch plant, maintenance areas, fabrication yards or buildings, staging areas and lay down areas. The project manager or planner usually performs the task of preparing the site layout based on his/her own knowledge and expertise. Apparently, this could result in layout that differ significantly from one person to another. To put this task into more perspective, researchers have introduced different approach to systematically plan the layout of construction site [7].

Therefore, the research seeks to assess the site layout practices of construction project in Abuja, Nigeria with a view to improve productivity on construction projects.

2. Literature Review

Characteristics of Site Layout Facilities

construction site facilities for a good site layout design are usually have a specific work target and operation nature in which they still have some common characteristics as follows.

- a. Essentially not easy to be substituted for carrying out specific construction work.
- b. These temporary facilities are by their nature being temporary as the name implies.
- c. The facilities should be properly located when positioning. In addition, if they are not positioned well they affects the efficiency of the construction productivity.
- d. If these temporary facilities are not positioned properly by use of effective site layout design, therefore the facilities may occupy significant workspaces and may affect the regular project of some major construction activities that are taking place.
- e. These facilities should meet requirement for relocation and meet the advancement of works and progress of construction.
- f. These facilities should meet requirement like safety, operational and structural concern.
- g. The provision of maintenance and the installation of these temporary facilities can

be quite timely and costly, thus the provision, relocation and maintenance and also dismantling of these facilities should be well planned in a very careful manner in order not to interrupted with the site layout design master plan of the construction project site [8].

Site Layout Planning Element

A well planned site, which comprises of all temporary facilities and utilities lead to

- i. Increasing productivity and safety.
- ii. Reducing areas needed for temporary construction and maximizing utilization.

The following elements should be considered in good site layout [9].

Site aaccessibility

Good and very easy accessibility will keep the morale of the equipment and the drivers of the vehicle, high minimization of the chances for the occurrence of accidents, and also save time in manoeuvring to arrive at and leave the project in a very good time. In case of large projects, proper planning is required to set the layout of roads which will lead from the nearest high. Internal roads are necessary for easy flow of vehicle as well as the flow of the work itself. And also parking lots are provided for the owner, office and craft personnel, but this facility must be planned where space does exist [9].

Security

It is very necessary to have a proper guard at the entrance of the construction project site. It should be provided by a booth also, it is necessary to keep track of all visitors entering in to the construction project site. Lighting is necessary to have a stand by generator for site lighting, fencing is necessary from the security check point to the entire site boundary [9].

Safety

The prevention of fire and other hazard that may arise at construction project site is every important. Fire outbreak is a major cause of damages at construction project

site. In this regards provision of fire extinguishers at construction project site is necessary because they are the basic requirements for the safety of fire [1].

Information signs

Site map is very necessary at construction project site to show the details of the project by displaying it in the construction project site office and at the entrance gate. This should be done by the construction project superintendent or the project manager and or the site planner.

- i. **Provision of traffic regulatory signs:** Traffic regulatory signs are usually considered on large scale project so as to guide the traffic and avoid any occurrence of accidents at the construction project site.
- ii. **Display of labour and management relation:** Safety rules and policy has to be provided this will help in eliminating the disputes that may arise between labour and management.
- iii. **Provision of emergency exit notes and underground services:** It is paramount important to display the emergency escape routes on every angle and floors, as the construction operation progresses. And also indication of the points were those underground facilities are necessary.

Office

The provision of site offices for all the project stake holders is necessary. The offices to be provided should be closely together. And close to the construction operation area at the construction site and in a safe and noise free area so that to prevent the noise of machines to the office. The offices should be well required with office equipment. The stake holder's offices should include the job office, the general contractor office, sub-contractor office and the project consultant's offices.

Accommodation: For large scale construction project provision of

accommodation for all the staffs involved in the project is necessary so that the work will be progressing with respect to time. [1].

Sanitation and water supply

It is very necessary to provide and supply water to all angle of the construction project site as well as the provision of public convenient for the staff around so that they will be comfortable. [9].

Storage and site cleaning

Storage facilities have to be provided for safe storage of construction materials so that unnecessary movement of materials will be arrived. [1].

Material handling

Provisions of materials handling equipment are necessary because almost one third or more of all construction operations can be classified as material handling. The proper use of the equipment for material handling and advance planning for minimizing the multiple handling will result in direct cost and time savings. [9].

Craft change-houses

Craft men on site has to be provided with change room and restroom for waiting of work shifting as well as store for clothes storage and washing area [9] .

Batch plant and fabrication shops

Batch plants are provided on projects where it is more economical to produce concrete as in situ in construction project site than to buy a ready mix. An onsite batch plant is accompanied by Aggregate storage piles, cement silos and tank for admixtures. Shops are used where material and equipment are fabricated on site. There is need for laboratory for testing of samples. This fabrication shops should include electrical, mechanical, carpentry and paint shops etc. [4].

Provision of Site Layout Facilities According to Construction Project Stages

Construction site layout facilities for a construction project site can be further be classified based on construction stages for a particular construction project site. This depends on the type and scale of the project. Some of this classification can be as follows.

- a. At the start of the construction project: construction site layout facilities are to be set-up at the early stage of construction project undertaking. This usually include the provisions that must be provided before the effective carrying out of other major construction works or other work items that are to be demanded for concerning statutory requirements. The facilities we are referring here could be site fencing, supply and routing of the access roads the setting up for site offices for contractors and other site personnel, arrangement for the delivery and also positioning for the essential work equipment, and other provision as required by relevant statutory requirements [8].
- b. At the peak period of a construction project that is as the construction project progresses to a peak point when permanent structural works are to be executed. At this stage, the facilities to be used for the construction project progress should be more specific some of these facilities are temporary in their nature. These facilities should be the tower crane, material hoist, workers lift, and scaffold, and temporary platform, provision of access working fronts, false work or additional support to the required structures. and other equipment, And there are also mounting equipment which are mostly required for external works for buildings such as power wincher system for the installation of other finishing materials like the curtain wall units which are to be operated a temporary provided track rail. [8].

- c. At final stage of construction project, that is when finishing touching activities are on progress or other handing over preparation is to be carried out. In this stage of construction project almost all the construction site layout facilities are to be dismantle and remove away from the construction site. Some particular equipment or facilities of different type required to assist in the temporary facilities. For instance like in case of a winching machine and a lifting rod that are to erected and set on the roof level to help in the dismantling process for a tower crane and lowering its components down to the ground level for removal. And therefore provision for the touching up & maintenance of the disturbed areas after the dismantling and removal of the temporary facilities is also required [10].
- v. Handling spaces for other building materials and semi-completed components which include precast items used on site.
- b. Large scale building construction projects in particular with a very large construction project site area or involves works on site with a complicated shape or layout. This comprises for instance large scale excavation, deep trench excavation, work adjacent slope or sensitive structures either at grade or underground [8].
- c. Complicated civil engineering project and various types of large-scale construction projects, example of these types of projects which include site formation, marine works, drainage works, slope treatment water supply railway construction, highways projects, tunnels and bridge construction and other infrastructural development projects. [8].

Provision of Major Site Layout Facilities According To Types of Construction

Construction site layout facilities is relatively a general term that in used for the setting up and operation of a construction project site for the nature, scale and type of works to safely and greatly diversity from construction project site to construction project. The following are features to be highlighted based on the construction project type [8].

- a. Building construction project involve the construction of super high rise storey building, towers in a relatively confined site the construction site layout facilities for project of this nature should include [8].
 - ii. Facilities and work spaces for construction material delivery or placing of concrete
 - iii. Crane tower is to be assisted for construction activities that are situated at the top floor level
 - iv. Hoisting equipment that is used in materials delivery or components which are structurally completed at various floors.

Provision for site layout temporary facilities for civil work projects are often in a highly dynamic nature due to the involved works that are mainly in a horizontally spread layout without a lot of tall and independent structures. The facilities and equipment needed for project of this nature are very heavy duty materials for the requirement to handle huge amount of materials or very heavy components or for the supporting of very large loading, very large operating spaces with additional equipment are normally required for the erection, manoeuvring operation and dismantling of these facilities. [8].

The following are example of some temporary facilities used in civil engineering works [8].

- i. Machines access road or worker manual, these accesses can be erected. Over large area that in undulating, down to deep excretion pit climb to great height or span between tall structures

- e.g. bridge towers, or provide access to very steep slope.
- ii. Provision of equipment for the transportation and lifting of bulky or very heavy materials such as the spoil materials for excavation for structural steel, precast or semi completed components. These materials can weigh up to hundred tons. The hundred equipment, for instance the various types of work machines for earth-work conveyors systems, cranes, launching equipment portal frame, hydraulic trolley or jack systems etc. sometimes, such provisions may even include the setting up of temporary facilities such as pier for marine works or for the delivery of large and heavy materials transported to site by sea. And of course, an appropriate access routing should also be provided for the working and handing of the equipment.
 - iii. False work system for various purposes such as support for temporary work platform for machine stationing for material handling and for storage facilities, provision of additional work spaces (elevated or suspended) so as to give support to lay span reinforced concrete structure which in constructed is an in-situ manner support for a working platform over an open-cut basement excavation pit or as support to freshly concreted structures which are prepared for the temporary placing of additional loading.
 - iv. Site layout and equipment for large scale earthworks, site formation for foundation works. A large number of very large work machines such as excavator, dumper trucks, graders, rock crusher, conveyor, drilling machine, piling rack for foundation large climates piling equipment are involved in these kinds of projects. This equipment here are often used in a difficult topographic condition mostly in remote areas, where in accessibility problem for the delivery of machines or even removal of excavated spoil away from the site. or

the work spot these machines are used and removed later in the earliest time they are mostly stationed in a location and removed in short period of time this is done when the work has been completed for progress of other works on site

- v. Equipment for specialized construction works such as launching of gantry for the construction of viaduct or elevated bridges, Tunnel Boring Machine (T.B.M), travelling of form work systems or the equipment for tensioning works etc. This equipment used for this purpose are usually very large sized and also very heavy in weight. They usually require a very large working area to place and consume time so as to place to a required location so that work will take place. These equipment has a lot of features [8].

3. Research Methodology

3.2 Research Method Adopted for the Study

The research involve answering question relating to site layout practices, and hence will use descriptive and case study approaches of carrying out research as described in Abdulazeez [11]. These form of research assess the practices of site layout practices as it relates to

3.3 Population and Sample

The population of this study consist majorly of the management of large construction firms in Abuja metropolis. This construction companies cuts across both those involved in building and civil works. The population size of the study is denoted by (**N**). The research used purposive sampling technique, which consist of construction companies in Abuja. A well-structured questionnaire was given to the management of these large construction firms to achieve the listed objectives of the research. The sample size of the study is denoted by (**n**).

The sample size is determined by using the Kish [12] formulae which is described as follows:

$$n = \frac{M}{1 + \frac{M}{N}}$$

Where n = sample size

N = total population

$$M = \frac{s^2}{V^2}$$

V = standard error of the sampling distribution

S = standard deviation of the population element

Using a total error of 0.1 at 95% confidence interval

V is 0.05 and P is 0.5

$$S^2 = 0.5 \times (1 - 0.5) = 0.25$$

N = 245. (Number of registered construction companies based in Abuja, according to C.A.C 2014.)

$$M = \frac{0.25}{0.0025} = 100$$

Hence

$$M = 100$$

$$n = \frac{100}{1 + \frac{100}{245}} = 71$$

Therefore the sample size (n) for the survey is found as 71. This implies that 71 questionnaires would be distributed across the construction companies based in Abuja.

Data collection technique

The questionnaire distributed to the large construction firms will be used in obtaining the research data as well as interviewing the respondents in order to gather information regarding to site layout design and management practices in large construction sites.

Administration of data collection instruments

Questionnaire will be administered to management staffs of the selected construction companies in the study area.

Data analysis technique

The research used the statistical package for social sciences (SPSS) as a tool in carrying out the statistical analysis for this study, which will act as both a descriptive and inferential tool.

Relative Importance Index (RII)

Relative importance index was used in the study to rank the site layout design practices of construction projects in Abuja.

$$\text{Relative Importance Index (RII)} = \frac{\sum fx}{\sum f} \times \frac{1}{k} \text{-----} 1.4$$

Where,

$\sum fx$ = is the total weight given to each attributes by the respondents.

$\sum f$ = is the total number or respondents in the sample.

K = is the highest weight on the likert scale. Ranking of the items under consideration was based on their RII values. The item with the highest RII value is ranked first (1) the next second (2) and so on.

The rating of all the factors for degree of significance was based on the value of their respective relative importance index (RII). The guide for the rating is given in Table 1.1 below:

Table 1. Guide to degree of significance

Degree of significance	Rating
Very significant	0.76 above
Significant	0.67-0.75
Fairly significant	0.45-0.66
Not significant	0.44 below

Source: Vanduhe [13]

4. Findings and Discussion

This part of the study deals with the presentation and interpretation of data obtained from the field survey, analysis of the data and discussion of findings as they relate to the objectives of the study.

Table 1: Breakdown of Questionnaire

	Respondents
No. Distributed	71
No. properly filled and returned	39
Percentage response	54.9%

Source: Field survey (2015)

From Table 4.1 seventy one (71) questionnaires were administered, thirty nine (39) questionnaires were returned. Based on the assertion of Moser and Kalton [14], the result of a survey could be considered significant if the response rate is not lower than 30-40%. Therefore, the percentage of the returned questionnaires is adequate for analysis.

Company Information

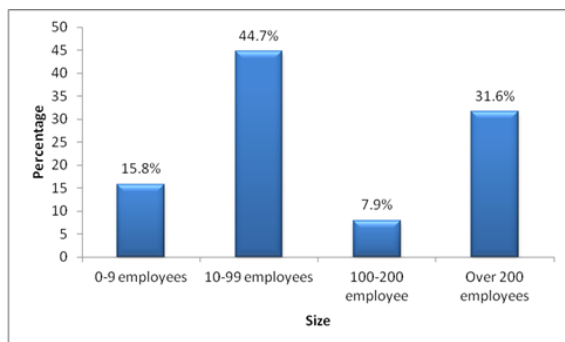


Figure 4.1: Size of the Company

Figure 4.1 shows the size of company, some companies have employees ranging 10-99 (44.7%). While those with employees between 100-200 have the lowest percentage of 7.9%. This implies that 44.7% of the construction companies have 10-99 employees. This may lead to under staff of workers in the construction company.

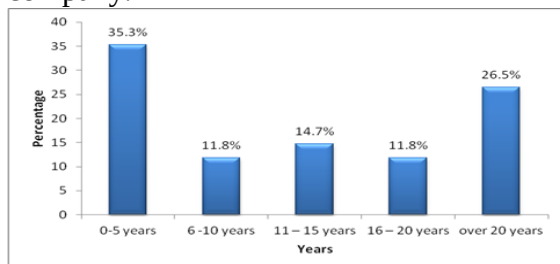


Figure 4.2: Years of Working Experience of Firm

Figure 4.2 shows the various years of experience of the construction firms, were by majority of the firms has 0-5years of working experience which result to 35.6% while the minority has 6-10years and 16-20years of working experience which result to 11.8% for both respectively. This may implies that 35.3% of the construction companies does not have much experience

unlike those that have experience of over 20years with a percentage of 26.5%.

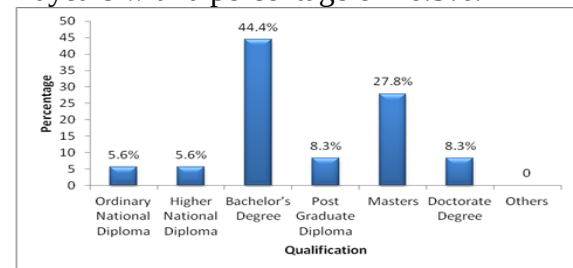


Figure 4.3: Highest Academic Qualification

Figure 4.3 shows the highest academic qualification of the staff in the construction project site, in which majority of the staff has bachelor's degree which result to 44.4% which implies that the construction companies have high number of professionals with bachelors' degree. While the minority has ordinary national diploma and higher national diploma which result to 5.6% for both respectively. While 8.3% of the construction companies have employees with doctorate degree this may be as result of lack of affordability by the construction companies to utilise much employees with doctorate degree in the construction companies.

Involvement of Construction Companies in Site Layout Practices

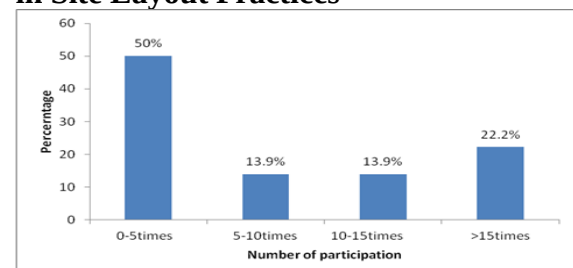


Figure 4.4 Number of Times of Participation in Designing Site Layout

Figure 4.4 shows the number of participation of the staff in designing site layout in which majority of the staff falls between 0-5times in designing site layout which result to 50% which implies that about half of the staff participated 5times or below. While the minority of the staffs' falls between 5-10times and 10-15times which result to 13.9% for both respectively. This may simply shows that majority of the

employees in the construction companies does not have much experience in designing site layout.

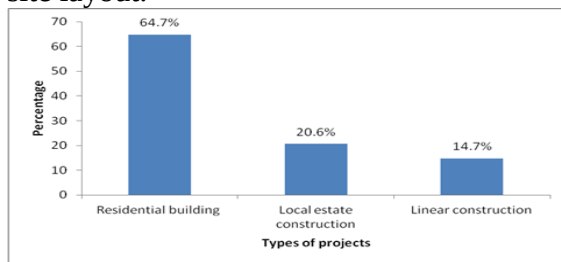


Figure 4.5 Type of Project with Site Layout Design

Figure 4.5 shows the type of project with site layout design, were as the majority of construction firms do site layout design for residential building construction project which result to 64.7% while the minority of the construction firms do site layout design for linear construction, which result to 14.7%. This may implies that majority of the construction companies does mostly building construction in which they may be have much experience upon.

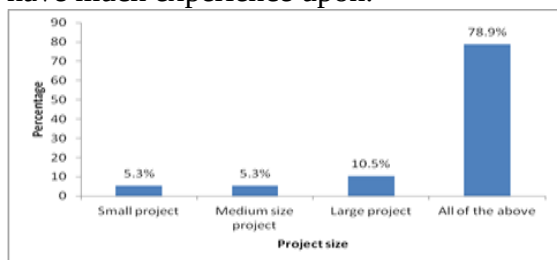


Figure 4.6 Project Size in Planning of Site Layout Design before the start of Construction Project

Figure 4.6 shows the project size in planning of site layout design before the start of construction project, were as majority of the firms does site layout design for small, medium and large project which result to 78.9% which while the minority does for small and medium size project which amount to 5.3% for both small and medium size respectively. This may implies that majority of the construction company does site layout design for all the kind of construction.

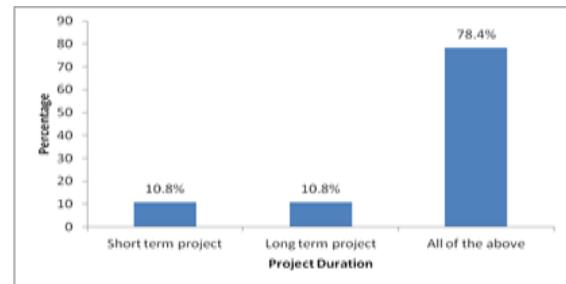


Figure 4.7 Project Duration in Site Layout Design in Construction

Figure 4.7 shows the project duration in site layout design in construction project, were by majority of the construction firms does site layout for both short and long term project which result to 78.4%. While half of the minority does site layout design for short term and the other half does for only long term duration project, in which it result to 10.8% respectively. Since the majority of the construction companies does site layout design for both short term and long term construction project this may be due to their consistency in construction.

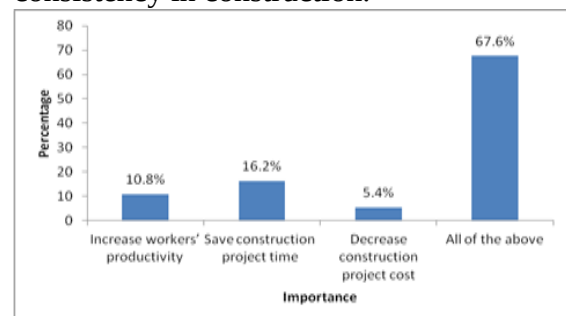


Figure 4.8: The Importance of Site Layout Design

Figure 4.8 shows the importance of site layout design, the majority of the construction firms benefits from all the importance of site layout design which leads to 67.6% while the minority benefits from only decrease in construction project cost, which leads to 5.4%. As the majority of the construction companies benefit from all the three importance of site layout design this may due to effective and proper use of their site layout design in the construction project sites.

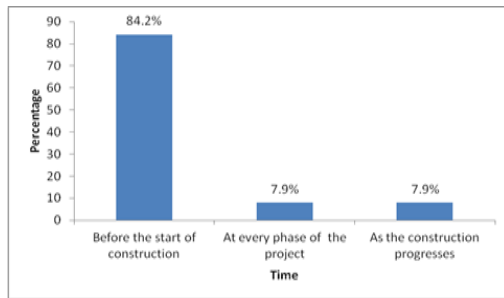


Figure 4.9 Time to Provide Site Layout Design in Construction

Figure 4.9 shows the time in which site layout design is to be provided, majority of the construction firms provide site layout design at the beginning of the construction project which result to 84.2%. While half of the minority provide site layout design at every phase of construction project and the

4.4 Site Layout Practices

other half provides as the construction project progresses which result up to 7.9% respectively.

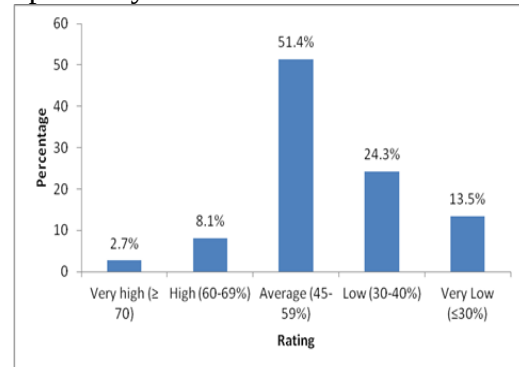


Figure 4.10: Level of Participation of your Engineers or Planners in Designing Site Layout.

Table 4.2: Site Layout Practices

S/No	Practices	Frequency of responses					Σf	Σfx	Mean	RII	Position
		1	2	3	4	5					
1	Preparing site layout designs before the commencement of site works	1	2	5	13	17	38	157	3.9	0.7	1st
2	Ensuring good positioning system for the temporary facilities.	3	5	5	16	7	36	127	3.1	0.635	7th
3	Construction of fence at the boundaries of construction site.	3	4	6	9	16	38	145	3.625	0.725	3rd
4	Provision of the public convenience for workers on site.	5	6	6	9	9	35	116	2.9	0.58	11th
5	Provision of canteen for workers meals at site	5	9	11	10	3	38	111	2.775	0.555	13th
6	Provision of workers recreational facilities	14	13	5	3	1	36	72	1.8	0.36	20th
7	Provision of first aid centers for workers emergency responses.	4	7	8	11	8	38	126	3.15	0.63	8th
8	Provision of access roads for trucks and light weight vehicle.	3	1	9	12	12	37	140	3.5	0.7	5th
9	Provision of site offices for clients, contractors and consultants.	2	2	8	14	12	38	146	3.65	0.73	2nd
10	Provision of security office	3	4	9	9	13	38	139	3.475	0.695	6th
11	Provision of security check points	8	7	14	4	2	35	90	2.25	0.45	18th
12	Provision of site clinic	12	9	12	2	2	37	84	2.1	0.42	19th
13	Provision of fire prevention and fire fighting equipment	6	9	11	7	5	38	110	2.75	0.55	13th
14	Provision of information signs and signals	4	4	10	13	6	37	124	3.1	0.62	10th
15	Provision of site map showing the site and temporary facilities	7	6	13	8	3	37	105	2.625	0.525	16th
16	Provision of traffic signs	6	8	11	7	5	37	108	2.7	0.54	15th
17	Provision of safe and safety equipment	1	7	6	18	4	36	125	3.125	0.625	9th
18	Provision of accommodation for site workers.	7	11	4	6	8	36	105	2.625	0.525	16th
19	Provision of site stores	4	2	5	13	14	38	145	3.625	0.725	3rd
20	Provision of fabrication and maintenance shop.	6	7	12	8	5	38	113	2.825	0.565	12th

Not applicable=1, low level of application=2, moderate level of application=3, High level of application=4, Highest level of application=5

Figure 4.10 shows the level of participation of your engineers or planners in designing site layout, majority of the engineers and or planners of the construction firms have averagely participated in designing site layout which result to 51.4%. While minority of the engineers and or planners have participated very high as in participating severally in designing site layout which result to the lowest percentage of 2.7%. As the majority of the engineers in the construction companies averagely participated in designing site layout this may be due to their years of experience of work at all.

Table 4.2 shows components of good site layout practice. 'Preparing site layout design before the commencement of site work' ranked first with (RII) value of 0.785 which is very significant. This implies that the construction companies prepare site layout design very well before the start of construction project; 'Provision of site offices for clients, contractors and consultants', ranked second with (RII) value of 0.73 which is significant. This implies that the construction companies practiced the provision of site offices for clients, contractors and consultant. 'Construction of fence at the boundaries of construction site', and 'provision of site stores' both ranked third position with (RII) value of 0.725 which are also significant. Which implies that they practiced it very well 'provision of access roads for trucks and light weight vehicle' is ranked as fifth position with RII value of 0.7 which is significant. This shows that the construction companies provide access roads for trucks and light weight vehicle very well. 'Provision of security office', ranked sixth position with (RII) value of 0.695 which is significant. This implies that the construction companies do the provision of security office very well. 'Ensuring good positioning system for the temporary facilities', ranked seventh with (RII) value of 0.635 is fairly significant, which implies that the construction companies fairly does

good positioning system of the temporary facilities. 'Provision of first aid canter for workers emergency responses' ranked eight positions with (RII) value of 0.63 which is also fairly significant. This shows that the construction companies fairly provide workers emergency responses i.e. first aid centre 'Provision of safe and safety equipment,' ranked as the ninth position with (RII) value of 0.625 which is fairly significant. Which implies that they fairly provide safe and safety equipment. 'Provision of information signs and signals' ranked as the tenth position with (RII) value of 0.62 which is also fairly significant. This is also considered as fairly practiced by the construction companies. 'Provision of workers recreational facilities ' ranked as the last position with (RII) value of 0.36 which is not significant. This implies that the construction companies do not practice the provision of workers recreational centres.

From the result obtained above it can be inferred that good site layout practice is majorly preparing site layout design before the commencement of site work, which takes care of the planning of activity on construction sites and controls movement on the site. The Provision of workers recreational facilities did not have significant impact on good site layout practice because it does not directly affect construction site activity.

5. Conclusion and Further Research

From the research it can be concluded that the construction companies are involved in site layout practices, usually at the beginning of every project, and they are reviewed between one to five times during the life of the project on a basis of short and long time. The engineers and planners are key players in the design of site layout plan and it can also be concluded that the major site layout practice is the preparation of site layout design before the commencement of site work.

The research therefore recommends that further studies should focus on assessing the duration of site layout plans in the life cycle of the project, and the roles of the professionals in the design and implementation of site layout plan. It also recommends that further studies should focus on the design considerations and processes involved in the implementation of site layout plan in construction projects.

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PROVISION OF PUBLIC RECREATION SPACE UNDER URBAN INTENSIFICATION POLICIES: CASE STUDIES FROM AUCKLAND, NEW ZEALAND

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Abstract

Public recreation space has been identified as an essential feature of the urban fabric; it provides opportunities for variety as well as environmental, physical, social and economic benefits. The traditional approach towards the provision of public recreation space is the 'standards' received increasing criticism due to its failure to meet people's recreational needs. Apart from this issue, urban intensification policy is seeking to increase density in existing activity centers. Population growth within the specified areas makes it difficult to apply a standard approach as limited land is available in urban areas, and it is costly. These issues have shifted attention from the 'standards' approach to a 'quality' approach as an alternative method, which instead of considering the amount of such space actually takes people's recreational needs into account and how to meet them in such space. The aim of this research to develop qualitative measures to evaluate public recreation space in intensified urban areas.

Keywords: *Public Recreation Space, Urban Intensification, Standard Approach, Quality Approach, Qualitative Measures*

1. Introduction

Urban 'public recreation space' (PRS) is well acknowledged as a contributing factor to the quality of life (Burgess et al., 1988). Urban public recreation space not only provides environmental benefits but also brings social, economic and cultural benefits, and contributes to the physical and psychological health of the population (Ulrich, 1981). Furthermore, public recreation space is important in enhancing the quality of urban areas. There are many studies highlighting the importance of such space in people's lives (e.g., Gold, 1972; Hayward & Weitzer, 1984; Kaplan, 1989; Swanwick et al., 2003; Chiesura, 2004; Dines & Cattell, 2008; Van Den Berg et al., 2010; Van Dillen et al., 2012; Cater & Horwitz, 2014; Jurkovič, 2014). For example, Hayward and Weitzer (1984) mentioned that public recreation space encourages physical exercise where this is ease of access as well as appropriate facilities. From another perspective, Dines and Cattell (2008) note that public recreation space is really a place where people connect with individuals who use

the same place, and a place which provides social benefits. Bishop et al. (2001) recognised that public recreation space helps individuals to relax and get away from the hustle-and-bustle of crowded cities, and use the concept of a 'sense of escape'. Ter (2011) notes that public recreation space provides "natural help" to overcome urban stress and therefore plays a significant role in improving the quality of daily urban life.

This study focus on the provision of PRS within intensified urban areas. Urban intensification policies are the core of urban planning in First World countries include the UK, North America, Australia and New Zealand. The main aim of urban intensification policies is to manage and limit growing urban population within brownfield and greenfield, in order to prevent the disadvantages of spreading out the developments (e.g., infrastructure cost, intense use of natural resources and travel cost). To this effect, more developments will be occurred within existing urban areas. According to the UK urban planning, 60 per cent of developments will be on

brownfield sites and 40 per cent will be on greenfield sites. Therefore, more population will be accommodated within brownfield. For example, in Auckland with population density of 2200 people/km², gross average density in city centers will be 50-200+ and the developments will be in form of apartment with nine stores and more. Accordingly, urban intensification will result in intensified use of land within existing activity city centers.

Different terms have been used to refer to place, where provide variety of services (e.g., provide basis for economic growth, employment, social interaction, investment and where integrate land use and transport and walking), and attract high number of people. For example, Melbourne 2030 planning for sustainable growth use the term 'activity center'. Auckland applies the term 'city centers' to refer to such place. In this study different terms interchangeably have been used which all refer to the urban area subject to intensification; such as city centers, activity city centers, existing urban areas, activity center, central activity district, intensified urban areas. Activity center can be divided into groups based on types and size, such as central activity district and neighborhood activity centers. Central activity district is where offers most variety of services and types of land use (e.g., commercial, office, residential, educational, recreational). This study focus on central activity district, which is known as activity city center.

In fact the focus of urban intensification policy is to develop and re-develop existing activity city centers to accommodate more population and activities. To achieve this aim, land within urban areas will be intensively used. This situation will impact other types of land use (non-built environments), such as PRS. Recent studies have explored the drawbacks of urban intensification, which reveal challenges that might impact the provision of PRS as follows:

First, a growing population requires more services and facilities. Therefore, by accommodating more population within existing activity city centers more facilities will be needed. The question that might raise is whether and to what extent meeting these requirements are possible. This question is addressed by Searle (2010), he pointed out that more population means more services and more PRS. He also argued that intensification result in losing or reducing private open space such as backyard, so to compensate this lost more PRS is required, to accommodate activities that used to occur in private open spaces. Second, more population will be accommodated with easy access to existing PRS. This is due to the fact that dwellings with easy access to PRS are more expensive, as such space contribute to quality of life (Searle, 2010). Accordingly, developers take advantage of the economic benefits of PRS by building more dwellings around PRS. Consequently, existing PRS will undergo intensive use. This situation will result in conflicts of use and over time might reduce the quality of space so people will lose their interest to use such space. Then, PRS under this circumstance might experience underuse. Therefore, the benefits of PRS can't be delivered fully.

Third, due to profits of new developments within existing urban areas, allocating land for built-up environments is at priority. This result in less available land to allocate for PRS and if any chance, it would be so costly.

According to Auckland's Unitary Plan (2013), "providing suitable land for new public recreation space or expanding the existing ones may not be available, and the cost of acquisition may be prohibitive" (Unitary Plan Issues Paper, 2013, page 3). Consequently, due to availability of land and funding challenges, PRS might fail to win in land use competition. As a result of less opportunity to provide PRS, benefits of PRS would not be fully delivered.

As discussed above, the challenges due to intensification might impact the delivery of the provision of PRS, consequently impact the delivery of the benefits. This situation shed light on the importance of reviewing laws and legislations in respond to these challenges, and councils approach in delivering the benefits of PRS under this circumstance.

The concept of public recreation space first appeared in Britain, and, by the end of nineteenth century, it was established in urban regions (Walker & Duffield, 1983). During the industrialization period in the nineteenth century, due to diseases caused by polluted air, addressed public recreation space as essential for the public as it provides fresh air (Cartwright, 1977; Walker & Duffield, 1983). Throughout the industrialization period, the requirements for public recreation space were increased (Maulan, 2002). In addition, in the nineteenth century in Britain, urban development shifted from low density to high density and caused a reduction in public recreation space. These circumstances highlighted the need to secure public recreation space.

One of the first advocates for such space was Richard Slaney (1883), who emphasis a mean to secure public recreation space. Based on his support of PRS provision, the Britain parliament developed legislation in the 1830s to provide parks and open spaces, and since then, the planning of such spaces has been integrated into the urban planning (Walker and Duffield, 1983). Since the integration of public recreation space laws to urban planning, councils have applied different policy instruments and methods to apply the legislations and provide PRS. Regarding the provision of PRS, three policy instruments have been applied. These instruments include acquisition of land, regulations and incentive-based approaches (Bengston et al., 2004).

First instrument is acquisition policy, which uses public investments in providing green infrastructure such as PRS as much as uses for other public services (Benedict and McMahon, 2002). Under acquisition policy, there is contribution policy, which developments are required to contribute land for public services such as urban PRS or help funding for public interest. For example, financial policies in Auckland allocated a contribution policy which bounded developers to contribute 7.5 per cent of new created subdivided or the value of equivalent of 20 square meters for each developed dwelling (Auckland Council Contributions Policy, 2015). However, a study, reviewing investments of funding in the 21st century in America, by Bebedict & McMahon (2002), found that there is no specific funding for green infrastructure rather it is financed with money that is left over after all other services have been provided.

A question that needs to be asked is how this contribution policy contribute to the provision of PRS within intensified urban areas. This can be illustrated briefly in the case of Portland, where urban intensification has been criticized for failing to deliver associated quality public recreation space in its downtown neighborhoods (Harnik, 2012). This is because Portland provides such space in the suburbs, thus offsetting the loss of public recreation space in the inner city and following standards. However, the aforementioned spaces are underutilized and do not fulfil the residents' requirements in intensified areas at the local level. One of the reasons for the failure of this approach is due to accessibility; as Whyte (1980) observed, easy access is one of the key factors resulting in use of a PRS, so delivering the benefits of PRS. This example reveals that regulations (e.g., contribution policies) and standards approach do not ensure the delivery of benefits of PRS.

Second fundamental policy instrument is the regulations' respond to the provision of public recreation space. Regulations are classified into two phases – before and after the First World War (West, 1973). Before the war, it was based on historical incidents instead of planning policies (West, 1973). However, during the time following the war, two main changes were made to how much such space was provided, the extent of the public recreation space required, considering equality in providing space and taking into account the location of space (Walker and Duffield, 1983). Since the integration of public recreation space regulation to urban planning, councils have applied different methods to apply the legislation (e.g., opportunistic models, system methods and standards method).

Land use policies apply opportunistic and space standards models as the most common methods for allocation land for public recreation space. Opportunistic model refers to land that become available by opportunities (Maruani & Amit-Cohen, 2007). For example, donated land by wealthy people for public use (e.g., Park Hanadiv in Zichron Yaakov and first major parks in London during the 19th century) (Maruani & Amit-Cohen, 2007). Also, left over planning land (such land is usually small and not suited for public recreation space), and demolition of slum areas provide opportunities for creating public recreation space (e.g., the Al-Azhar Park project in Cairo, and boulevards in Paris) (Maruani & Amit-Cohen, 2007). A fundamental question that is raised is whether there will be any such opportunities for provision of PRS within intensified urban areas. However, too little attention have been paid in this concern.

In 1925, standards appeared in urban planning for allocating land for use of public recreation space. Since then, standards approach have been used widely in different contexts and most studies have focused on how much land and where

should be provided for such space. Standard method refers to land units per person and is based only quantitative data. Standards approach specifies the amount of such space. However, the standards approach has received increasing criticism due to its perceived failure to provide quality spaces and to meet people's recreational needs (Byrne & Sipe, 2010; Jurkovič, 2014). Gold (1972) argues that the failure of the standards approach is evident in underutilized neighbourhood public recreation spaces as they are created based on standards and ignorance of peoples' actual recreational needs. This is supported by Harnik (2010), who discussed the importance of recognizing people's recreational needs rather than specifying standards to motivate the use of such space.

Standards approach have received criticisms not just due to ignorance of people's recreational needs, but also its application in urban intensification contexts. As discussed early urban intensification will result in less available and costly land, therefore, to attempt to meet the recreational needs of increasing populations by applying standards in these contexts would be very difficult. One question that need to be asked is how by facing this difficulties, PRS is provided. An international review reveal that different strategies have been applied to compromise these challenges. For example, in 2006, New York converted central railroad to High Line Park; another example is converting road to PRS such as Oxford Street Park. Therefore, one strategy would be to convert under use space to PRS. Nevertheless, it is not clear that how and to what extend such strategy is applicable in other intensified cities. Another strategy would be to create roof garden, however, the main aim of this is to deliver ecological benefits rather than social benefits. These examples show that applying standards approach in urban intensification is not well applicable, so resulted in different ad-hoc strategies. However, far too little attention

has been paid on how to deliver social benefits within intensified urban areas.

Third policy instrument is incentive-based approach. Over the past thirty years incentives followed political priorities, aim to centralized developments within existing activity city centers. Accordingly, existing activity city centers considered as an economic growth site. Therefore, incentives are used to attract investments and to orient development within existing urban areas. These incentives include subsidized land costs, tax exemptions or reductions, improvements to infrastructure, reduction of development fees, low-interest loans, assistance in securing zoning changes, and others (Nelson and Duncan, 1995; Porter, 1997). For example, in Texas, developers are exempted to pay for development fee.

Therefore, on one hand, contribution policy charges developments to contribute to public services and result in providing PRS outside the intensified sites, due to lack of available and costly land. On the other hand, incentives policy, which is based on political priorities, motivates more investments and developments within existing activity city centers. This situation results in contradictions between regulations and political process. This study draws on these contradictions to identify how social benefits of PRS is delivered within intensified urban areas, to this effect, this study will identify how urban intensification might impact the provision of PRS.

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COLLABORATIVE FACETS IN DESIGN STUDIO: TOWARDS ESTABLISHING A DESIGN-DRIVEN LEARNING FRAMEWORK

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Abstract

The influenced of contemporary conditions such as climate change, urban migration, technological advancement, Information and communication technology (ICT), may obligate a transformation in architectural design education where Information and Communication Technology (ICT) might take the significant role for the transformation. Designing been a fundamental activity that supports the introduction, development and implementation of products, services, practices, and systems; greater understanding of the methods, strategies, and tactics employed by designers in facilitating design activities should enable us to uncover certain unique characteristics of the design process. This study expounds research possibilities based on a Design-driven Learning (DDL) Framework by examining exemplary cases in architectural education. Through current literature review, the study has identified DDL as a learning process that entails progressive and productive cognitive and behavioral transformation during knowledge integration between stored, reflective and generic domains of knowledge. The study found that the studio environment provides students with high imaginative potential and score excellent results. Further study can investigate between two groups of student designers working in a different environment.

Keywords: Collaborative Facets, Design Studio, Design Driven Learning Framework, Knowledge Integration

1. Introduction

Students of Architecture usually carry out their design project alone without collaborating with other AEC disciplines. However, in real life practice design is a collaborative responsibility of AEC disciplines. Then why it is not so to design learning? Why is design learning contrary the design practice? Eventually, the dichotomy creates a lack of designers' ability to learn how to effectively collaborate with other disciplines as required by some of the contemporary design conditions.

With the current proliferation of Building Information Modeling (BIM) across the world, the next generation of architects and designers are expected to have a wide range of knowledge and skills of collaboration. Collaborative teamwork has a significant impact on the implementation, networking, learning, understand, communication and representation on BIM. The knowledge and skills of collaboration will help design

students to effectively participate in the modern construction world as proliferated by the BIM concept. Therefore, there is the need to have a collaborative design learning among AEC students (8). Likewise, this study examined the conventional design learning environment and proposed the DDL framework to explore the role of collaboration in design learning. Potentials designers are expected to be familiar with multidisciplinary criticism, consultation, and knowledge. Therefore, to achieve integrated project delivery and innovative ideas among potential architects and engineers, there is the need to have a collaborative design learning system that will serve as a networking tool for building designers (6; 10). Students will learn how to use and manage latest information and communication technology (ICT) tools that will foster development and progress in team practices. They can also develop their problem-solving skill where necessary.

2. Literature Review

The influenced of contemporary conditions such as climate change, urban migration, technological advancement, Information and communication technology (ICT), obligates a transformation in architectural design education where Information and Communication Technology (ICT) taken a significant role in the transformation (12). Architectural design education should be a collaborative system where design learning should include students and tutors of other disciplines like engineering and quantity surveying (12) (5). There is the need to develop and adopt a proper architectural design education strategy that will ensure effective collaboration among students and tutors of other disciplines like engineering and quantity survey. The architectural education will then serve as a medium that provides design student with the required skills and experience of managing collaborative process even before graduation. Adequate integration of some collaborative parameters into the current design learning strategy might be a way forward (12; 3; 9).

Being a fundamental activity that supports the introduction, development and implementation of products, services, practices, and systems, the greater understanding of design learning methods, strategies, and tactics employed by designers in facilitating design activities can lead to some unique characteristics of the collaborative process, particularly in design learning. However, conventional design learning offers a pedagogical approach as opposed to the 'grounded' outlook of the dedicated design practice. These led to the further disintegration of the design learning among the AEC related disciplines. For example, design learning circumscribes under the pedagogical framework of problem-based learning. These contrasts the view of more established design researchers who consider the design paradigm as markedly different from the problem-based

framework. Therefore this study expounds a Design-driven Learning (DDL) Framework after examining the architectural design learning environment. Video recordings and subject interview are employed to elucidate the use of DDL parameters in the design case study. The study is expected to capture and measure collaboration in the reflective world of the DDL environment, and also to open up possibilities for future studies in Collaborative design learning.

Literature established that design learning was originated in the 1950s, in the Bauhaus school of Design Germany, under the nomenclature of Studio-Based Learning (SBL) (3). From Germany, the SBL was copied and adopted and distributed by Ecole des Beaux-arts in Paris in the same century. The studio is the environment that offers design learning course for Art and Architectural students. The studio set-up provides the student with a deeper knowledge of design and self-oriented problem-solving training in design fields of Architecture, Landscape Architecture, Interior Design, and Industrial Design. A studio is a place where students are assigned a task to generate and present the solution for the given task using continuous iteration of concepts until the design concept is refined and communicated. Therefore, the introduction of the studio in design learning provides a dynamic space where designers learn how to develop their design skills. The design studio is considered to be a professional way of learning design with the aid of an expert designer as Supervisor, Master or Teacher. Collaboration works are expected to be innovative and efficient when compared with the work of lonners. Collaboration fosters the development of integrated projects, testing, and adoption of new ideas. Therefore integrating collaborative studio learning across the AEC disciplines is important (6; 4). Literature studies carried out across Europe, Asia and the USA (13; 1; 2) on collaborative teamwork across the AEC

disciplines has to prove to be an important aspect of a learning platform for the AEC disciplines. Other studies indicated some universities have developed and adopted their collaborative design course (11; 13; 7; 2).

3. Research Methods

The aim of this research is to investigate and identify the collaborative method in design learning for the potential contemporary collaborative design learning. Among methods of studying design, activities are protocol studies using protocol observation and interview. The proposed methods for this study includes; content analysis, close group discussion, and protocol coding. Protocol study was chosen as the research methodology for this study because of its ability to study design activities through behavior, verbalization, and gestures. Protocol analysis is a widely used technique to study design processes found in architecture. The study observed an experiment that involves a design studio class. The study used stages of experimental design, subject recruitment, conducting experiments, transcribing protocols, coding schemes, quantitative and qualitative comparisons and the final result outcome. The three different research methods use for this study includes close group discussions, literature review, and observation. Through these methods, the study background was setup and tested. The observation consists of the subjects (students and design tutors), design task, supporting tools, and studio environment. The proposed subjects are architecture students and design tutors.

4. Analysis & Results

The retrospective observation of the studio activities and subject interviews revealed some unique features of collaboration during the design learning. The identified features include progressive and productive iterations and knowledge interaction. The analysis also indicates that design learning is a working system that involves developing solutions to real life problems

through the interchange of knowledge. Collaboration between tutor and students is a major medium of design learning.

Table 1. Collaboration in design learning environment (DDL)

Collaborative facets	Examples
Progressive Transformation	
Create idea	Generate (I ¹)
Evaluate idea	Simulate (I ²)
Implement idea	Develop (I ³)
Productive Transformation	
Directive feedback	Correction (F ¹)
Corrective feedback	Improve (F ²)
Review feedback	Reduce (F ³)
Guidance feedback	Instruct (F ⁴)
Iterations	
Prototyping	Staging (T ¹)
Scaffolding	Linking (T ²)
Knowledge Integration	
Stored Knowledge	Abstract ideas (K ¹)
Reflective Knowledge	Experiential ideas (K ²)
Generic Knowledge	Product (K ³)

5. Discussion & Conclusion

The DDL framework (Figure 1.0) is aimed to serve as a design learning strategy that entails collaborative parameters such as progressive and, productive transformation and knowledge integration (stored, reflective and generic domains of knowledge). Stored knowledge is the abstract knowledge; reflective knowledge is the exploration, refinement, and synthesis. Generic knowledge is the artefact. The video observation and subjects interview validation established certain unique features of collaboration during knowledge integration process. The collaborative parameters emerged during knowledge reflection of tutor and students. Such archetypical collaborative ‘mode’ lends itself to our important ‘unit of research inquiry. It encompasses the study and measure of design thinking patterns, design problem-solving iterations, ideation and conceptualization processes as well as feedback. This study has found collaboration as a system that channel effective knowledge transformation

between tutors and students in a typical DDL environment of Architectural higher education.

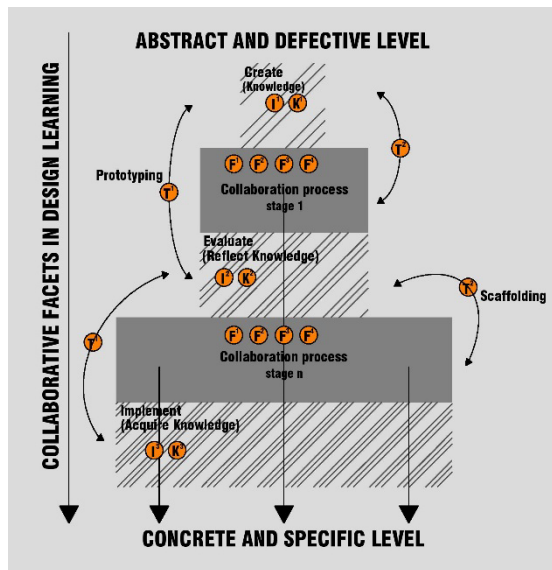


Figure 1.0 Design-driven Learning Framework (DDL)

The process of knowledge integration is the infiltration of abstract knowledge and reflective knowledge in generating generic knowledge. These process of infiltration and generation occurs when a designer (student) uses imagery to access abstract knowledge in generating design concept, and further use perception and experience as reflective knowledge to refine, explore and synthesize the initial concept of the design to achieve the outcome of the design as the generic knowledge. The iterations facilitate refinement, syntheses, exploration and some premature resolution during presentation and consultation.

The interview also established that all both students and tutors agreed that collaboration in the design learning environment improves their knowledge and skills of solving design problems better than a non-studio environment. Further studies on two group of student designers working in a different environment is a potential area of future research. The environment that elicited high score will be more suitable for a potential collaborative design learning environment.

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COPING GENDER INEQUALITY THROUGH HOME BASED WORK: A STUDY OF ADAPTIVE MICRO SCALE WORK ENVIRONMENTS IN KORAIL SLUM, DHAKA

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Abstract

In Dhaka, capital of Bangladesh, slums are the natural consequence of rapid unplanned urbanization and poor economic growth. Women living in slums face acute gender inequality due to higher level of poverty and lower level of education. Using Korail slum as a case study area, the study investigates how women facing gender inequality use home based work in adapted micro-scale work environments' as coping mechanism. Using observation, interview and focus group discussion as research tools, the study attempts to identify these apparently mundane spaces and their role in everyday life of the women living in slums. Findings show, the female workers have a spontaneous ability for cultural adaptations and creating home based work environments for survival. The study will possibly contribute in identifying the spontaneous space typologies that help female slum dwellers earn their livelihood and in coping with gender inequality which can guide possible future intervention and/or external support.

Keywords: Home Based Work, Slum, Gender Inequality, Adaptive Micro Scale Work Environments, Female Workers

1. Introduction

According to UN-Habitat estimates, nearly 863 million people live in slum conditions [1]. It is expected that if the situation remains same, the number will probably double by 2030. Categorical terms like *slum*, can disguise significant cultural and economic distinctions among low-income settlements. Various known as *informal* or *non-formal cities*, *squatter settlements*, or *shantytowns*, these communities differ dramatically in size, character, age, and level of political and social organization [2]. However, few characteristics remain common: separation from urban infrastructures such as roads, sewers, transportation, water and electricity supply, storm-water management; having severe health, environmental, security problems and lack of public facilities such as cultural, economic or recreational activities.

In Bangladesh about 30% of the population live in urban areas (Table 1). Dhaka, the capital of Bangladesh, is a mega city of 15.4 million people [3] with the greater urban

area encompassing approximately 1,530 square km [4]. The city is now experiencing a rapid population growth much higher than the rest of the country (Table 1). Especially over the past four decades, Dhaka's population grew exponentially. This can be attributed to gradual changes in demographic, economic and social fabric. A more specific source is migrants from over populated rural areas; often victims of natural calamities, landlessness and poverty. Annually, the city draws an estimated 300,000 to 400,000 mostly poor migrants who provide critical employment for the city's industries and services. Roy and Sarker [5] observes: "Although urbanization is often associated with increasing national production and high per capita GDP, poverty remains a persistent feature of the urban life, both in terms of income and living conditions". The economic growth has failed to keep up the same pace mainly due to poor political decisions. According to Bangladesh Bureau of Statistics (BBS), the yearly per capita income of Bangladesh is \$1,314 as in 2015

[6]. In 2014, of the 15.4 million people of Dhaka city [7], up to 6.9% was living in slums [8].

Table 1: Growth of national and urban population (million) in Bangladesh, 2000-2015, Source: [9]

Year	Total National Population (Million)	Annual growth rate of national Population (%)	Total urban Population (Million)	Urban Population as % of total Population (level of urbanization)	Density (P/Sq km)	Migrants (net)
2000	132.38	2.01	31.23	24	1,114	-151,224
2005	143.14	1.57	36.69	26	1,101	-400,001
2010	151.13	1.09	42.15	28	1,049	-714,191
2014	158.51	1.22	47.33	30	994	-456,443
2015	160.41	1.20	48.72	30	919	-408,112

Slums are the natural consequence of rapid unplanned urbanization and poor economic growth. Housing is widely regarded as an essential human need and right, as reflected in its incorporation into the Millennium Development Goals (MDG). MDG 7, Target D states, "Achieve, by 2020, a significant improvement in the lives of at least 100 million slum dwellers" [10]. As most slums are developed illegally, the government, NGOs and donors generally do not provide basic services such as water, sanitation, electricity, health and education in these areas. Also, close to 80 percent of slums are located on privately owned land creating considerable institutional challenges in terms of basic service provision [11]. There are between 16 to 40 different bodies involved in one way or another in urban matters in Dhaka with little coordination and planning [11]. As a result, there are major gaps in provision of services and infrastructure.

The poor are more vulnerable as they do not have the resources to meet basic needs. Even though slums provide very basic access to shelter for women, gender equality and female empowerment still remains elusive. Despite the expanding economic, social and political opportunities for women that come with rapid urbanization, gender inequality for women living in slums remains a persistent problem in Dhaka. A possible coping mechanism for

women is home based work. This paper studies the adaptive micro scale work environments in slums of Dhaka and how they help in coping gender inequality through home based work.

2. Gender inequality in slums

UN Millennium project (2002 to 2006) states in Target 4 under Goal 3 (Promote Gender Equality and Empower Women): "Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015" [12]. Lack of education, gender inequality and lack of women's basic rights has its root in lack of knowledge, ambiguous legal systems and their lack of application, socio-cultural emphasis on the prerogatives of males and their blood relations, etc. In many cases, it appears to be *equality in rights* in principle, but this is not the case in reality. These inequalities are more acute in slums due to higher level of poverty and lower level of education, especially among the women. In general, the greater society has male bias in terms of inheritance and owning property.

Gender equality in rights to land and housing has been established in a number of international treaties and conventions, including Article 16 of CEDAW (Convention of the Elimination of all Forms of Discrimination against Women) [13]. As there is no land ownership in slums, the

security of owning property is non-existent among men, let alone women. The most common gender disparities in slums happen due to women's limited access to stable employment and earnings, finance and credit. The limited ownership of movable properties effectively equates with male control over women and there is widespread discrimination against women in nearly all aspects. Even within the context of living illegally in slums, women have to face eviction and/or homelessness in the event of divorce or desertion. A highly vulnerable group facing gender inequality are the widows whose spouses die of natural causes or accidents leaving no one to look after them. In dire circumstances, they have to adapt various demeaning and immoral strategies such as prostitution for survival. On very rare occasions where government or NGOs take limited rehabilitation projects for slum dwellers, the units are generally allotted to the head of household i.e. men. Single women without male 'guardians' face a different type of gender discrimination. A single woman is automatically assumed to be of bad character. Due to societal pressure, it is often difficult for single women to find accommodation even in slums. Field study shows that women mostly cope with this inequality and earn their place in society with home based work.

3. Home based work

Urban informal sector constitutes a significant part of economy in large cities. Yasmeen [14] stresses on the importance of urban informal sector in developing countries where population and demand for jobs, goods and services grows too quickly for the formal sector to cope with. It is a survival strategy as well, especially in many countries that has no effective social safety nets such as pension schemes, unemployment insurance, etc. Informal sector businesses can take advantage of

personal and domestic assets, such as living quarters, vehicles, and furniture which helps them survive [15, 16].

Ghafur [17] states, home-based income generation takes place within a given dwelling and its broader physical context. Charms [18] defines home based (also known as household or unincorporated) enterprises by their legal status and type of accounts that distinguishes them from formal corporations. They are not separate legal entities independent of the household members that own them. Also, they don't have a complete set of accounts which could permit a clear distinction between the production and other activities of their owners. Home based enterprises (HBEs) help especially when formal wages diminish or cease. They start in the only place available - at home; with advantages such as little overhead cost, availability of household resources such as space and utility connections. They provide opportunity to trade off resources between domestic and productive activities, to save time and money as travel to work is not necessary, to make effective use of social and human resources such as relatives/friends in exchange of small sums of money or benefits in kind; and especially to enable women to have productive work even in social conditions where their movement and social intercourse are restricted (See studies by [19-26]).

Home based work promotes self-employment opportunities and helps to establish a close work-home relationship [27]. One great advantage of the home base work enterprises is they facilitate the entrepreneurs, especially women to release their creative energy and earning potential maintaining privacy, which is often more agreeable with the local cultural and religious context.

Table 2: Different types of home based work by gender and space required, source: author.

Type of Home based work	Gender	Approximate space required (square ft/person)
Traditional painting	Male	15
Woodcarving	Male	20
Hand-stitching (Garment)	Female	12
Handloom/weaving	Male	50
Tailoring/sewing (Garment)	Male/ Female	12
Embellishment/ embroidery (Garment)	Female	20
Chumki/Karchupi setting (sequins and jewellery)	Female	15
Cooking	Female	20
Bamboo products	Male/Female	25
Pottery	Male/Female	60
Agarbati-candle making	Male/Female	18
Bidi (local cigarette) rolling	Female	15
Broom making	Male/Female	20

They also help through self-sustaining and self-financing developments. Some of the disadvantages are the risk of crime involved, endangering overstretched municipal services, environmental degradation, fire hazards and increasing noise pollution [28]. Home based workers can be subdivided into two broad categories: self-employed workers and sub-contracted workers. The majority of the two are the *home workers* who are subcontracted to carry out paid work for firms/businesses or their intermediaries, typically on a piece-rate basis. This has important policy implications as there are distinction between self-employed home-based and sub-contracted home workers as they have varying levels of decision-making power.

In Dhaka, home-based work cuts across different branches of industry (see Table 2). It is an important category, representing a significant share of urban employment. It accounts for about one fourth of the urban informal employment. Some of these occupations are gender-specific. Industries including cooking, stitching, making bamboo products, pottery, broom making, certain types of stitching are commonly done by women, and traditional painting and woodcarving are commonly done by

men. Some occupations involve both women and men but with each specializing at different stages of production (e.g., weaving by male workers and then embellishment of *Jamdani* sari by female workers).

In Dhaka, the vast majority of home-based workers are women. Women face greater challenges when they want to start home based work. The scope of home based work is greatly limited by overcrowding, lack of space, lack of financial assets, etc. Those who can overcome these obstacles and actually start home based work occupy the bottom links of value chains in most cases. They earn little as they have to pay the overhead costs of production such as space, utilities and equipment. Some of the common problems faced by women are irregular work orders, arbitrary rejection of goods and delayed payments [29]. Home-based female workers have direct contact with the market and buy their own raw material facing competition from larger and more powerful formal businesses. They often do not have access to credit except at exorbitant rates of interests from local community sources. They lack bargaining power and social protection and remain largely invisible and voiceless. However, this scenario can partially improve if the

overhead cost of renting a space can be substituted with a spontaneous micro scale adapted work environment.

4. Research Approach

It has been recognized that space and the built environment are constituted by, as well as constitutive of gender, in feminist analyses of the city, even if the 'private' space of the household has tended to be somewhat neglected in mainstream theory [30-32]. In developing countries, women lag behind socially, economically and politically even though in most cases they are demographically superior in urban areas. The problem is more acute among the slum dwellers where gender-equitable access to 'decent' work and living environments is nearly absent. Gendered spaces play an important role in balancing this, albeit in limited capacity.

While there has been studies about the need of home based work in terms of its capacity for direct livelihood support, there has been very little research and documentation on how home based work empowers women to cope with gender inequality in slums. Also, there has been little research done on adaptive micro scale work environments as forum for the home based work from an architectural perspective. This is particularly critical in slums because of two issues: lack of adequate space and gender discrimination in terms of ownership of household spaces.

In this context, this study examines gender inequality and coping mechanisms (adapted by women) through home based work in the slums of Dhaka city. The study focuses on how micro scale adaptive home based work environments help in coping gender

inequality. After pilot survey of several urban slums, Korail slum of Dhaka was selected as the case study area. The area has been developed and occupied by more than 18,000 poor households with no security of tenure. The area was selected as it has a high concentrations of female home-based workers with a strong social network and all the other critical components of an urban slum in central city. The study uses observation, interview supplemented with focus group discussions with female home-based workers to identify these spaces and their role as coping mechanism in everyday life of the women living in slums. The aim was to include self employed home-based workers as well as sub-contracted home-based workers. The survey was conducted with female home-based workers, followed by focus group discussions involving the survey participants. These were supplemented by additional interviews with city officials, NGO and development workers. In the survey, individual, family- and community-based conditions were considered to illustrate the circumstances and challenges facing female home-based workers.

The findings of this study will possibly contribute to identifying the spontaneous space typologies that help female slum dwellers earn their livelihood and in coping with gender inequality. This in turn can help to guide future urban expansion where these types of spaces can be integrated informally or formally. While the data from observation and interview is primary; this study has the limitation of using secondary data to suggest various demographic and related trends. To gather data in such a large scale to form these trends was beyond the scope of this study.



Fig 1: Aerial view of Korail slum, Dhaka, source: [33] and author.

5. Coping strategies: Micro scale adaptive work environments in Korail

Korail, just like any other typical urban slum, has been growing with no administrative control, providing the dwellers with maximum freedom to build. Unlike other slums that grow on neglected urban lands, the spaces has been grabbed from Gulshan lake, a prime water body at the centre of an upscale residential area. Over the period of about three decades, the slum has gradually transformed into a substantial area blocking an entire part of the lake. In Korail, about 70-80% of the land is taken up for housing with maximum ground-coverage (Figure 1). The density is high, providing some of the cheapest and most affordable minimal shelters.

Korail slum is one of the best examples of “pirate urbanism”[2] appearing near an important city center (Gulshan) enabled by local political support, bribes, etc. Initially, there was no infrastructure in Korail during the 1980s. Municipal services were gradually added during the next two decades as slum-dwellers constituted a sizable urban population. Korail has a vibrant community with a wide range of social and communal spaces and facilities. This ranges from parochial spaces at the door step providing minimal space for social interaction to larger community gathering spaces for social activities.

The houses are generally single storied with some having two stories. The dwelling units are some of the smallest shelters possible. The living spaces are not mono-functional,

they serve multiple purpose and often they are not even typical rooms. Family functions, interactions and work overlap to create some of the best examples of optimum utilized living spaces. As the slum dwellers occupy their units, the adjacent spaces, both towards the lake and in between the units are up for micro scale additions. These additions are not done overnight, it's a slow and gradual process. After a certain period of time, the spaces become their 'own'. However, they are smart enough not to invest too much on these spaces; the construction is temporary or semi-permanent in nature, often having only roof and minimum enclosure (Figure 2, 3 and 4).

Most of the female home based workers work in slums. Their dwellings are small and crowded with little infrastructure, water connection, drainage, sanitation, light and ventilation. The lack of or poor quality of these services in turn effects their productivity. Frequent evictions and insecurity of tenure makes them even more vulnerable. Spaces are overcrowded and require constant reorganization for different activities. Amidst these realities, they find an 'escape' in the form of micro scale work places often in the form of an extension and alteration of the main house. In most cases, the micro scale adaptive spaces were not originally part of the household. Serendipitously they become a part of the households and in time becomes inseparable corners of home based work. They are invariably partial, provisional, and often experimental; relying on the idea of replicability: where a neighbour uses

similar solutions and copies to create a space of her own. However, economic conditions greatly influence the decision of materials and types of construction. These spaces display indigenous creativity of

design, spatial and social adaptation. It supports the idea that poverty of resources doesn't have to result in poverty of imagination.



Fig 2: Home based female workers in micro scale adaptive work environments, source: author



Fig 3: A housing cluster at Korail slum, left - before and right - after addition of micro scale work spaces, source: author

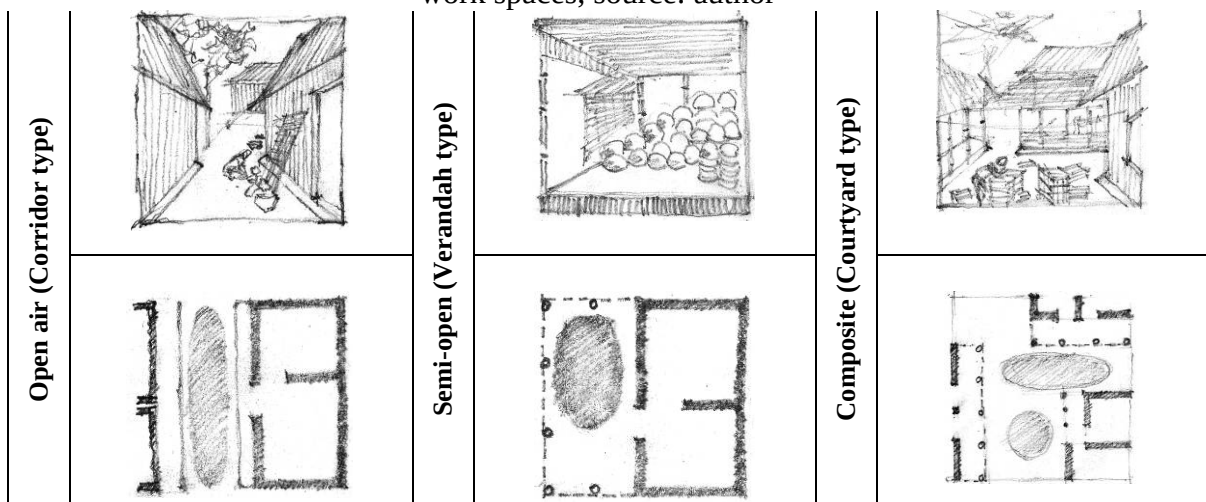


Fig 4: Basic typology of micro scale adaptive work environments at Korail slum, author

source:

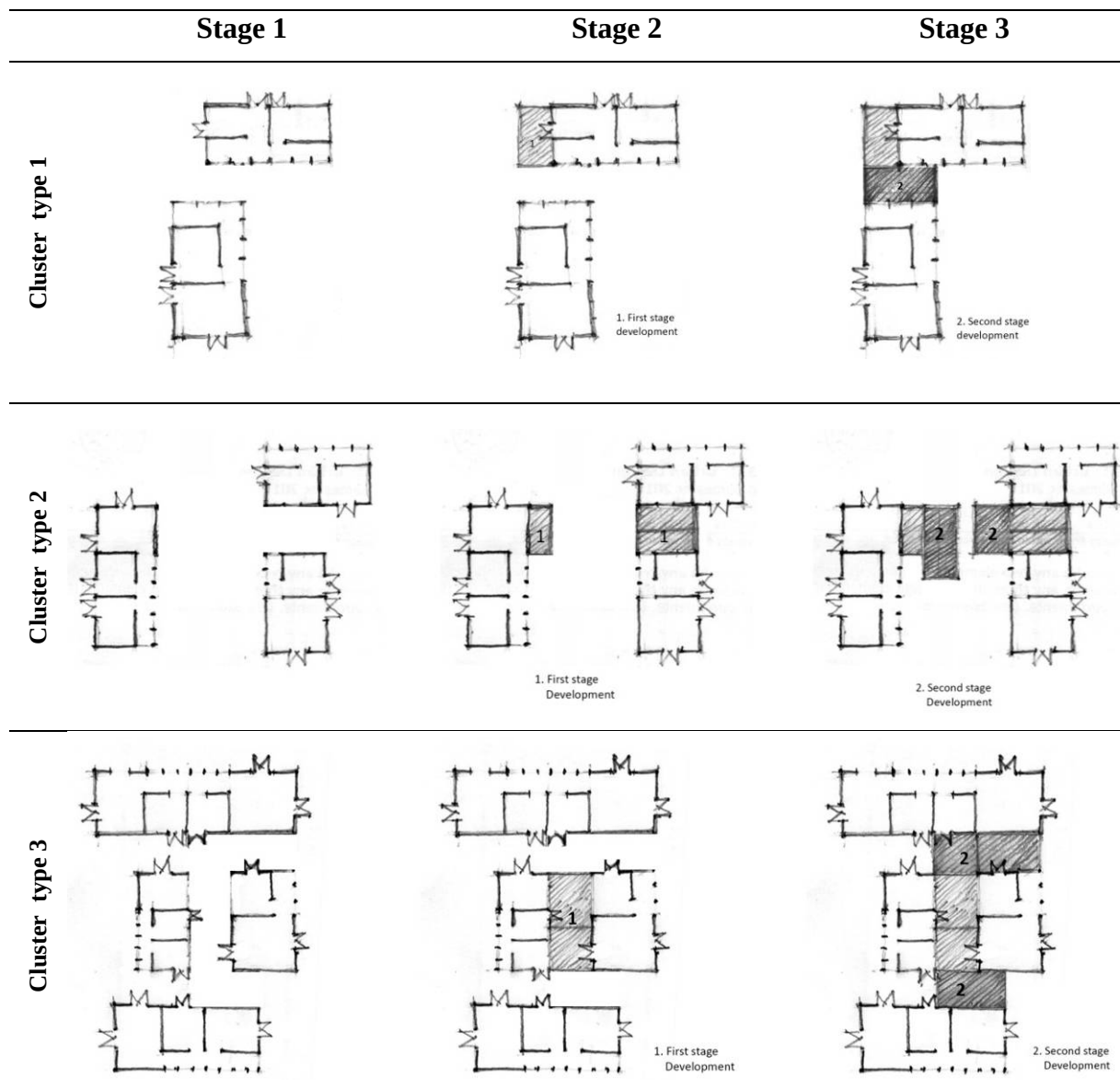


Fig 5: Different housing cluster types and development stages of micro scale adaptive work environments at Korail slum, source: author

Figure 4 shows three basic types of micro-scale adapted work spaces with activity zones highlighted. Depending on whether they are open air (corridor type), semi-open (verandah type) or composite (courtyard type), home based works vary significantly. For example, activities such as making bamboo, coconut fibre based products is possible in open air, activities such as traditional painting, handloom/weaving, cooking requires semi-open or covered spaces while activities such as pottery requires both covered and open spaces, i.e. composite type.

Figure 5 shows three cluster types and the encroachments that take place in stages. The first stage additions generally extends or connects the most private part of the dwellings where the public access level remains unharmed. This stage generally facilitates establishment of home based businesses. Once businesses start to prosper more space is required, leading to stage 2 of the encroachment. Here more public spaces are grabbed. As cluster type 1 and 2 shows, stage 2 development has significantly narrowed the public access. This is even more dire in cluster type 3 where the public access is entirely blocked (Fig 3 and 5).

This type of encroachment happens where the dwellers have a greater level of social influence.

The micro-scale work environments are some of the best examples of optimum use of resource, primarily land, often making use of negative spaces to the advantage and consolidating the entire development. A typical unit generally consists of a simple dwelling unit with a multi-functional living space with a kitchen alcove, shared service/wash area. The flexibility to build incrementally within adjacent spaces of the dwellings units is closely related to their semi-permanent nature. They are built with locally available materials such as new and used corrugated iron and tin sheets, timber rafters, country tiles, joists and posts, plastic sheets and other recycled materials. The extended micro-scale work spaces mostly use recycled materials such as used corrugated iron sheets, light bamboo fences, etc.

Even though the space they take is illegally occupied, home based enterprises of Korail helps in survival in struggling economic conditions adding to average household income and the general welfare of the local neighborhoods through positive activities (which otherwise could be used for anti-social activities). Women's participation in labor force is pivotal for survival of most households. Despite scarce resources, women take on productive roles as well as engaging in community with micro-scale work spaces as their stage.

They also contribute to social security of woman through economic freedom as they gain a better status in the household. The study shows that (Figure 2) provides not only means of survival but a much needed hope for women living in slums who otherwise would have been unemployed. It restores the power balance, albeit partially. Even though social security is minimum; finance and institutional support (often from NGOs) gradually becomes available

when the home based businesses have some kind of physical existence in the micro-scale spaces.

Whether for its construction or improvement, investment in a new space or acquiring one is a gender biased practice. This is mostly related to decision-making power, awareness, knowledge and perception of members of the household which is mostly male dominated. As micro-scale work spaces don't require a significant new investment they happen gradually and serendipitously; establishing women's role in the household.

The micro-scale spaces stand in a neutral ground where no extra resource is required by the households and there is no conflict between established norms (gender roles) and emerging needs in the households. This presents a new spatial practice where women find their economic and social space keeping the gender dynamics, which, in turn, influences and alters social processes as well. In the long run this spatial practice and adaptive capacity of individuals within a house or a neighborhood enables women to cope with gender inequality.

6. Discussion and Conclusion

Settlements such as Korail have become too large and old. It is impractical to think of eradicating them entirely, especially since sufficient vacant land to relocate them is scarce in Dhaka. Leaving the slums where they are may initially seem cumbersome and arguably more expensive, but relocation has often lead to gentrification. Also, developing infrastructure has the advantage of leaving the local economic and social networks intact, supporting local initiatives.

In Korail, women face difficult and complex socio-economic conditions. The study shows that they have a spontaneous ability for cultural adaptations and creating home-work environments as survival

strategies which can guide future interventions. The challenge remains for city managers to use this urban phenomenon (micro scale work environments) positively, gradually making them a part of the system.

The female workers could do better with external support as they are struggling. NGOs have been working in slums such as Korail; they can support the female workers acting as facilitators to bridge the gaps between the overall slum community and struggling female workers. Support can come in the form of small scale improvements (aided by local initiatives) which may inspire others and more comprehensive upgrades where female workers can join micro scale spaces into larger entities where space and work can consolidate. This has the potential to influence and improve employment infrastructures for female workers in slums significantly. However, any support should consider the real social, economic and financial challenges and it should enable community action.

Female workers are mostly under-skilled and poorly trained. Their empowerment is a vital issue. This can be achieved with motivating change in social and economic capital. The existing resources (skills, space, etc.) may be minimal but these can be strategically used to support female home based enterprises through active participation in decision-making. The micro scale work spaces provide a strong cue to what approach should be taken by the NGOs or government. Then the solution will be place specific and appropriate.

Gender bias is deep rooted in society; the female workers in struggling economic conditions especially suffer from social, cultural, economic, legal and political discrimination. The study shows how provision of physical spaces for work helps them cope. These spaces, 'insignificant' to bare eye, actually create a stage where

future institutional input, infrastructure development and possible stakeholders' (such as NGOs, industry, academic and research institutions, international organizations, etc.) support may become possible. A new insight and vision is required to sustain this existing phenomenon (where women spontaneously finds a way to cope) for a more humane home-work environment for women living in slums. There are no set of best practices. However, considering numerous infrastructural, economic, environmental, and social failures of recent urban policies (where slums are mostly ignored); the possible initiatives from stakeholders can contribute in their small way as a solution to social and spatial inequalities in slums.

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ACQUAINTANCE WITH PERSIAN GARDEN

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Garden, this domesticated nature, at the same time, contains aesthetic values, and usefulness is high and, due to its multiple value affects all five senses. What is certain in Iran in arid and water scarce climate, identify the natural environment requires knowledge, experience and a special technology which in Iran it has a very ancient history. From ancient pattern to the paradises of the Islamic era, the art of Iranian garden creation in water supply saving, irrigation and water views, plant coverage according to the usefulness and beauty, creating a micro-climate and locating, has provoked wonder and curiosity of researchers over time until now. Method of information collection was library based and in this research the quiddity of Persian garden is going to be described from different perspectives (Geometric, physical and functional).

Keywords: Persian Garden, Anatomy, Function, Climate, Water

1. Introduction

Persian garden Category can be seen as a phenomenon riding on the heart of time. When will necessarily economically and in the lives of generations can also bring distinct sense of routine and we also find is that dialogue and, apart from interest, love, enjoy receive semantic times its capital also is displayed. Suburban and urban gardens within us despite all the deeds that are, in essence, that belong to the generation that has long lived in the land of garden.¹The question that arises here is that the Iranians first built the gardens, following what have been?

Persian Garden confined space with its mystery and memory of the place and could not remain in their own territory. It covers an area beyond the wall, including the natural environment, cultural and environmental potential that are located around it and beyond mere physical nature and objective of the association. Garden art tradition in the country of great age and long history as one of the main school gardens in the world. From ancient times until the 19th century, relying on empirical knowledge to be hidden gardeners understand and complete structure created an environment that reflects the close

relationship between the natural and cultural context, and also a sign of consistency and alignment of human needs and nature. Garden in addition to natural beauty and usefulness in the context of sustainability rotation, has played a major role and can regulate the ecosystem becomes rich.

2. Literature Review**2.1- Garden:**

In 1982 in Florence Charter Historic Gardens Committee presented a description of the Garden: The garden is an architectural composition of inanimate objects, plants alive and represents the work of every nation, culture and climate, is home.

The main structure of all the historic gardens in the world based on the architecture of nature and synthetic or mixed method plants, water and buildings that regulate the body to create a suitable space for human life.

What garden as cultural and natural heritage in any place apart from other places, layers of meaning, the meaning and the physical and functional characteristics specific to each region.

2.2- Persian Garden:

Cultural phenomenon, historically, body in Iran and is usually confined area where plants, water and buildings in the distinctive architecture are combined with the favorable environment, provide safe and comfortable to humans, are made be.

Persian Garden " Link auspicious beauty and usefulness.² " Appearance Being and appearance are allows us to hear the voice of the universe ... Persian garden as a work of art should be invaluable in the process of spiritual art recognition. Recognizing the Persian Garden, the world's spiritual sound of the universe.³

In other words, the Persian garden space that combines natural and synthetic architectural structures such as water plants, meaning that embodies the visionary and imaginative.

2.3- A comprehensive model of Persian Gardens:

Based on research by doctor A. Masoudi reference pattern Persian garden can be seen as an early example of the intersection between Iran and the pattern in the carpet Persian gardens with garden plot flag is crystallized.

If chronological based approach based on the development of concepts and components that form the garden set, we act reference pattern Persian garden is described as follows:

The relatively large square or rectangular area that is enclosed by a wall around it. The level of this range with two axes (two atmospheric) intersecting perpendicular to each divided into four equal parts. Water from the fountain located in Mercer dock at the intersection of these two axes, erupted into four climate-driven and watering the trees in the square surfaces. The main building of the garden (Pavilion) at the intersection of two axes takes place.

3. Research Methods

Qualitative method to study the nature of Iranian gardens historical gardens and orchards Iran to recognize this is done on the basis of the existing library documents. In this study, three geometric point of view, physical and functional in the garden of continuing to refer Iran's case to be investigated.

4. Analysis & Results

4.1- The geometric structure:

In the simplest description of the geometric structure of the Persian garden to say, square or rectangular shape of the garden in full and proportional to the volume of water that can provide it. "In relation to the water and has a garden area garden area is enough water in the dehydration also can irrigate the garden."⁴

The earth is shaped to fit the characteristics of the ground (flat with general slope of the low, sloping, etc.) on a regular geometry or terracing of the plot.

The ground based on the three-axis or two axes parallel and perpendicular to the cross and divided into areas and each area of the square divisions that each of these divisions can be divided into squares, Crete classified there. Persian garden is built based on the geometry of square and rectangular predominantly is a perfect square.

In some studies the main cause of Crete Square Garden, ease of irrigation noted that "we have been common in agriculture thousands of years ago."⁵

Geometry imposed on Iranian gardens as a tool for cultural belief considered to be abstract, that is expressed environmental conditions in Iran "involves mathematics, the most abstract scientific application of science to the possibility, but the on the other hand abstraction, the material world absorbed in thought makes divine infinity of the world."⁶

If the geometry of visibility means we will also examine the geometry of the system is not limited only to the appearance of the garden, but the system as a tool abstract geometric relationship between the body of the human mind.

"When we move in the Persian Garden, the farthest point of the garden, the nearest point it looks. It can still be of geometry, but geometry is that the mind can understand it and live with it everyday interaction and pure that you walk to say, do ..." ⁷

The geometric structure of the multilateral system on a corpus of Persian garden Persian garden are:

- The main infrastructure and integration of natural and artificial elements of physical systems is a Persian garden.
- Organize and regulate the division of the land so that maximum possible use of the earth's surface is provided.
- It comes to agriculture.
- The irrigation system has been prevalent in the last matches.
- Virtualization creates a range based on the human optical illusion based on the main axis of the garden spots and places farther or closer than the actual size of his eyes.
- In addition to the physical geometry, geometry assumed creates a bond between the garden and the mindset of people.
- As a means to abstract cultural beliefs fit the paradigm has been at any period.

4.2- Functional systems of Persian garden:

Persian garden designs in different historical periods in its general form has no adverse change because we can say that the Iranian garden is a method, not a type.⁸ Persian garden can be used as linking the built environment and nature in Iran, according to the function of the buildings in which they were located, elements or special designs can also be categorized vast.

So far, the basis of various criteria Categories in Iran's gardens, including:

- Extent
- Functionality: residential gardens, public gardens, garden location - governmental, garden tomb and orchard.⁹ As well as government, Lords, and public ritual.¹⁰
- Design and physical characteristics of the land where the garden: The garden flat and low slope, steep gardens and with podium, packed gallery, garden constructed in complicated natural lands and gardens with lakes and rivers in the urban fabric.¹¹
- Climate
- The geography of the city and wrapping area Garden: Garden of Isfahan, gardens Caspian, Tehran gardens, orchards and gardens of Shiraz in the north and south.¹²
- Historical periods: the period of Achaemenid, Sassanid, ..., Safavid, ...¹³
 - The interplay of the garden, and the environment as well as specific elements: Garden tent, garden grille, garden pavilion and ...¹⁴

4.3- Persian Garden physical systems:

All historic gardens shaped body of three planting systems, water, and therefore the

system according to the climate and culture of each territory other than the territory is variable. Structure of a variety of natural and synthetic systems combined, and in fact the result of combining the body of the garden and the quality of its system.

According to Dr. Mir fendereski: "Garden as much as possible simple and clear material are formed and ambiguity in the relationship between man and does not leave space ... in arranging and creating an atmosphere of Persian garden, for clarity, applied mathematics it is. Because Persian garden is enclosed with a fence rectangular and with axes perpendicular and parallel to the sides of the fence divided the navigation system and other system-related settlement geometric garden including irrigation systems, planting system and architecture system provides. " ¹⁵

- Planting system

Planting the garden Iran, affecting the geometric structure and it is affected. On the one hand practical sense, planting and agricultural practices led to the creation of geometry knows and on the other hand planting system is also influenced by the geometry so that the planting of trees and plants mentioned in the Persian Garden and the geometry of the intertwining of water feature is has been known.

Plots on the basis of logical order, extent of coordination, follow the directions and specifications of the environment, efficient use of sun, wind resistance, confrontation and hatred with maximum heating comfort and abundance of the harvest, providing a quiet and refined environment, diversify contact air and dynamic beauty, are partitioned.¹⁶ Planting locations and any of the trees, flowers or plants is unclear.

Planting of the main axis of vision in regard to the location of the pavilion highlights and so on to see the importance of moving its main axis. So for linear, surface and volume of crop cultivation practices are the result, in the garden create

different visual qualities among which we can mention the following:

- create closeness in sight to overshadow by planting trees.
- Create major and minor axes Diderot instead of the aisle in the garden.
- Create virtual density by planting practices.
- Vertical axis view with high emphasis on planting trees and creating green body.
- Create a cone angle of view instead of in the main axis.

Planting a variety of trees and plants attract birds in different seasons and thus causes the Sweet sound of their garden space to be filled. Also, the breeze passing through the trees and plants, according to the morphological features and the planting of specific sounds are created.

Planting and growing flowers in the garden Persian Iranians to express interest in spreading fragrance fragrant garden space and it was. In addition to edible vegetables and herbaceous plants are also used for treatment. Medicinal herbs of Crete and in the sun away from the palace garden to be planted.

- Water system

Water generated from the garden and in Iran, where two-thirds of its land area is hot and dry, water supply, water extraction, water conductivity, water sharing and use of water with unparalleled accuracy and sensitivity, as well as the application of science and technology with a special permit be. The most important sources of water is, underground water and heavenly water. Underground water resources are driven by aqueduct to the garden and with a special system appears to be diverse while also providing various needs.

Water flowing movement on the ground and to the public in accordance with the slope geometry, linear water in the garden creates. Atmospheric circulation within the permanent plots but plots with irrigation water and sink it to the next plot flows. But the water in the gutter of the main shaft at the foot of trees for smooth passes and is always displayed.

One of the important characteristics of the water system in the Persian Garden, a high tendency to display it, because water was usually very low and very dear, it was a strange garden architecture building games and played over water into the ground indescribability and carried out.¹⁷ this is in addition to wasting (evaporation of water in hot weather) to minimize water provides a beautiful view.

Water Show not only for linearly moving streams, Water handlers and get up around dock that can be seen in the garden but also making normal pressure water jets that were made on the basis of law related containers may boosting moving the water vertically from bottom to top and thus creates a vertical line.

Large water storage in reservoirs for use in low water seasons of the year and the vast areas of water in their water levels reflection will show. The water level in the pool or shallow horizontal plane and in particular with different forms of squares, rectangles and polygons are displayed. The water in the order of reflectivity transparent surfaces planting rows of trees reflected in water level caused on the vertical axis and in terms of emphasis and the virtual area or infinity adds more garden space.

Forms a linear, surface and water volume to respond adequately to the needs of various Persian garden as well because water has a variety of functions, the system of irrigation water in the garden requires both mental and Blue Shells fit any of the trees and plants as well as accountable

Since the circulation of water in the garden begins the task of clean water is transferred. Water system, sound system and system features landscape garden is very effective.

Water movement and find it hidden in the garden in addition to displaying the various sounds created in the garden. "Move, water colors, the sound of water, the water and even water in a small pond and a large and various forms, hope and life instrument. The sound of the song is agreeable to hear, and a wave of water from the pond to the man comes, forgiveness or compassion is subtle and delicate. " ¹⁸

- Buildings settlement system

Iranian gardens buildings establishment of the system in the building and all synthetic elements order, organize the garden space and in combination with planting system and water system to the physical integrity of the garden. Buildings settlement system as well as two other systems on the geometric structure and elements of man-made garden conform to the shape of land and buildings, is based on it. In addition to building physical structures and systems as well as system deployment, other elements also determines the garden.

All the elements in the Iranian garden to garden enclosed by walls and fences as a framework for all these elements is derived. A literature review showed that in describing the Persian garden all researchers on the wall surrounding the garden as one of the main physical characteristics of Iran has maintained garden and it is considered for various functions, which include protecting garden in the top security functions animals wild and expressive injury Reading garden products, garden and protect its residents against the attacks of enemies and conquer it and also create a lack of mental peace with security for residents and climate functions, including the protection of Garden of the wind blowing hot and

dry, the sand mental status keep moisture in the garden and create more shadows that give rise to differences inside and outside the garden.

Garden buildings are made in two sizes: large-scale and small-scale partnerships like that in the main garden-like atmosphere that defines the garden. Major monuments like the garden often devoted to life outside and small buildings like the inner life in the form of small courtyards or rooms around the entrance to the sides of the chamber wings are usually in. Like the original spatial order and geometry on the small garden not.

Large scale like: Mansion entrance of the house, the main palace building, usually in the upper chamber axis parallel to the main garden and the garden are large-sized buildings that are like them by matching the military establishment The geometric structure of the garden is done so that in the Iranian garden geometry open space in the garden is the geometry of the buildings and assign to them gives meaning.¹⁹ Thus the great buildings like the great visual emphasis can be seen in the perspective of the main axis of the garden.

Small scale-like: Other garden buildings such as bathrooms, stables and storage services function, and in some cases (according to the climate and the orientation of the garden in the overall deployment) predominantly summer, winter Location staff and crew also featured predominantly in the especially in the walled garden and confining walls assign fall garden. The buildings garden space in the garden for outdoor enclosures are not distorted.²⁰ on a small scale like what is important is that the garden area (empty but full of nature) have perfect geometric shape and not offensive in any way with any building on it.

Buildings in the garden full deployment of square or rectangular space within the garden so that the system follows the perspective of the garden to showcase a

perfect geometric figure. That's why sometimes irregular spaces located within the walls outside garden area expands. In fact, regular geometric shape-finding inner space of the center, mainly of open space, the beginning and towards the outside grows, and indoor the non-visible from the outside, the irregularities surrounding tissue, compact and comes with different measures be coordinated.

5. Discussion & Conclusion

Iranian garden architecture system, how to discipline Find all natural elements, artificial physical systems (planting, water and the establishment of structures) identified a he does. By examining the physical system became clear that physical Persian garden design very careful and calculated based on the geometric structure formed, mainly in the form of a perfect square or rectangular outer perimeter of the garden, and the garden with the walls relatively long enclosed clearly isolated from the surrounding environment. In this way, the walls of the elements defined in the Persian garden space would be enclosed garden and the separation of the two areas of garden space both inside and outside stresses and therefore introduces clear boundaries.

So in the Persian Garden definite boundaries between inside and outside the garden, on a square or rectangle defined geometric shape. But in addition to the geometric proportions delimitation of outer, inner space divided basis as well. The overall atmosphere of compliance within the geometric structure and perpendicular lines can be divided into smaller spaces. The system determines the geometric structure detailed physical plan of the garden, so that the outer boundary of the garden, water systems, planting system and settlement system of buildings, based on the structure defined so that all categories of tangible definite boundaries and visible.

On the one hand there is the prospect of the long main straight and stretched the

garden, in front of the pavilion and planting tall trees on either side of a central role in the creation of the garden longer perspective effects, and on the other hand, which in most of the gardens of the natural slope Iranian used a perfect opportunity for wrapping pavilion in the garden provides a high point and low point of human vision when placed on your distance to the elevated point less than the time until the distance feel the high point looks. The Persian garden, with its natural context of implementation of the factors and creating a virtual vastness and infinity of space in terms of the system.

In Persian Garden has witnessed the transition from space to space Garden else. Basically, the most important architectural features combined built in Persian garden and the garden and the two sometimes it felt so mixed that cannot be terminated where the gardens and where to get started. The use of sensory stimuli such individuals to create a continuous space, including the qualities of the Persian garden is a garden. The Persian garden space in the garden, not cut, but rather a man of the past and linked with other garden spaces. Inside the garden space to cannot create life and contour. Picture the kind of interference in their water and mix of garden and building. Integration, interaction, integration and garden space Iranian border, by the geometric relationship, the relationship between visual, sensory, primarily related to the physical characteristics of buildings in the garden and wrapping them. This emphasis on continuity of space gives the definite boundaries between space and a space without boundaries become blurred.

Finally, we can say that the fusion of the physical architecture of the Persian garden planting, water, settlement building, shadow, sound, system landscape based on geometric structure, determines the shape of the space in the garden: continuous Without Borders, midway between outside and inside, a large man with a sense of

unlimited synergy that takes a refreshing and soul in it.

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AN EVALUATION OF THE SUCCESS OF PUBLIC-PRIVATE PARTNERSHIP (PPP) HOUSING PROJECT IN ABUJA, NIGERIA

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Abstract

Recently, there is an increasing reliance on public-private partnerships (PPP) in the provision of housing and associated infrastructure. Although monitoring and evaluation are crucial components of most PPP policies, the performance of many PPP projects are self-defined by the advocating governments. The ineffectual evaluation of PPP projects would trigger a costly loss of competitive value and would lead to delivery of products or services below optimum quality. Using Structural Equation Modelling (SEM) approach, this article evaluates the success of the PPP housing project in Abuja, Nigeria. The findings of the study indicate that the factors “favourable investment environment”, “efficient procurement process” and “appropriate risk allocation” have significant influence on the success of the PPP housing project in Abuja, Nigeria. The findings should assist PPP stakeholders to improve their understanding of the factors that influence the success of PPP housing projects in Nigeria.

Keywords: Success Evaluation, Public-Private Partnership, Housing Projects, Nigeria

1. Introduction

Inadequate finances throughout the developing world is seriously outstripping the capacity of most governments to match the demand for housing and public infrastructure with an adequate provision (1). The developing countries of the world are witnessing an extreme financing need for housing and associated infrastructure projects beyond the capacity of the public sector (2). Consequently, many states adopt public-private partnership (PPP) as an alternative delivery strategy (3).

In order to meet the burgeoning housing need in Abuja, the FCTA introduced the mass housing scheme in the year 2000 under its public-private partnership (PPP) program. The program aims to bridge the wide gap between the supply and demand in housing stock in the federal capital territory (FCT). While the government is to provide primary infrastructure and allocate land to private developers under the scheme, the private developers, on the other hand, are to provide secondary and tertiary

infrastructure as well as develop and sell houses to members of the general public.

However, the scheme recorded little success (4) due to lack of adequate planning (5) and implementation (6). With a success rate of 32.25 % (5), the scheme could not deliver the much-desired housing units to the residents of the federal capital territory.

The increasing reliance on public-private partnerships in the provision of infrastructure and services is well documented (7). However, in worldwide practices, the application of PPP has not always been positive (8, 9). With the mixed story, debate on PPPs has currently shifted focus towards evaluating the explanatory factors that account for success of PPP projects. To maintain effectiveness in a highly competitive markets, the performance of PPP projects need to be properly evaluated (10).

This article focuses on evaluating the success of the PPP housing project in

Abuja, Nigeria. The article reviewed literature on measurement of project success and success of PPP projects. Using a structural equation modelling approach, this article evaluates the extent of contribution of critical factors in the success of the PPP housing project in the study area.

2. Literature Review

2.1 Measurement of project success

Project success remains a complex attribute (11) because the accuracy of its measurement depends largely upon the method adopted by the assessor (12). As described by (13), success is an intangible perceptive feeling whose measuring criteria varied among persons, phases of the project and with management objectives. Success is one of the most subjective term used in project management (14) and many of the claims for PPP success are self-defined by those making the assessments (15).

Various authors adopt different dimensions for measuring project success. For instance, (16) categorized the measurement of project success into four dimensions. The first dimension relates to project 'effectiveness' regarding whether the project is completed on time and within specified budget. The second dimension, which is customer oriented, relates to 'when' the project is delivered to the beneficiaries and whether it meets the functional requirement and technical specifications. The third dimension, which relates to 'business performance', is regarding whether the project has achieved cycle time, yield and quality and overall improvement of organization performance. The fourth dimension concerns long term and future 'outcomes' of the project.

On the other hand, (17) suggests that project success should be evaluated at two levels: project outcome and participant satisfaction. Using a comprehensive approach, (18) developed four criteria to assess project success. These criteria include safety, economy, time and

flexibility to users. As supported by (19), a successful project is one that is achieved on a budget, on time, conforms to specifications, users' expectations, quality workmanship and minimize construction exacerbation. Further developing from the works of (20), (21) included technology transfer, and friendliness of environment as measures project success.

2.2 The success of PPP projects

Public-private partnership is a long-term contractual relationship between public and private entities to share risk for the design, construction, and operation of infrastructure or services (22). It involves various processes and a great deal of input from both the public and private sectors, with the major aim of achieving project success.

Over the last three decades, public-private partnership has gained popularity as one of the most viable options for remedying the observed inefficiency in traditional service delivery approaches (23). However, the international experience with PPP has not always been positive (24). The mixed results in the application of PPP have, therefore, called for an evaluation of PPP projects to establish the explanatory factors that influence their success or failure. Accordingly, many studies employed the concept of critical success factors to evaluate the success of PPP projects. Critical Success Factors (CSFs) are those few key areas, which if satisfactory, will ensure successful performance of an organization or project (25). The understanding of the critical success factors is key to achieving success (26).

Many authors have developed various list of factors critical to the success of PPP projects. For instance, (27) identified factors influencing the success and failure of Build-Operate-Transfer (BOT) infrastructure development in Asia, (28) identified success factors that contribute to the achievement of best value in PFI projects in UK. (29) identified CSFs for

public-private partnership implementation in the telecommunication sector in Lebanon. (30) identified eight independent CSFs for Build, Own and Transfer (BOT) projects in China. (31) identified CSFs from reflection of an Australian sports stadium project. Table 1 gives a list of critical factors that influence the success of PPP projects based on the review of previous literature.

Table 1: List of CSFs of PPP projects

CSFs	Authors
Transparent procurement process	Li et al. (2005), Chan et al. (2012), Babatunde et al. (2012), Hwang et al. (2012)
Competitive procurement process	Hardcastle et al. (2005), Hemming (2006a), Atmo and Duffield (2014)
Good governance	Hayllar (2010), Helmy (2011), Ismail (2013)
Well-organized and committed public agency	National Audit Office, (2001); Scharle (2002), Hemming (2006b); Li et al (2005); Cheung et al (2012) Aigbavboa et al. (2014)
Trust and openness between parties	Ong and Lenard (2002), Jamali(2004a), Armitage and Susilawati (2004), Karlsen et al. (2008), Robinson et al. (2010)
Stable political system	Babatunde et al. (2012), El-Sawalhi and Mansour (2014)
Stable economic system	Helmy (2011), Chan et al. (2012), Babatunde et al. (2012)
Efficient legal framework	Li et al. (2005), Abdul- Aziz and Kassim (2011), Babatunde et al. (2012)
Availability of financial market	Hwang et al. (2012), Ismail (2013), Li et al. (2005)
Supportive community	Heinke and Wei (2000), EFCA (2001), Ng et al. (2010)
Government guarantee	Hemming (2006a), Jamali (2004b), Chan et al. (2012)
Efficient approval process	Jefferies et al (2002)
Consistent monitoring	Abdul- Aziz and Kassim (2011)
Action against errant developers	Abdul- Aziz and Kassim (2011)
Equitable risk allocation in contractual agreement	Thomson et al. (2005), Li et al. (2005), Zhang (2005), Jin and Doloï (2008), Kwak et al (2009), UN-Habitat (2011)
Equitable risk allocation in operational agreement	Hwang et al. (2012), Muhammed et al. (2012), Wibowo and Alfen (2015), Ameyaw and Chan (2015)
Equitable risk allocation in loan agreement	Zhang (2005), Nsasira et al. (2013)
Equitable risk allocation in design/build contract agreement	Zhang (2005), Nsasira et al. (2013)
Technical competence	Jefferies (2002), Zhang (2005)
Financial capability	Jefferies (2002), Zhang (2005)
Rich experience in partnering	Li et al. (2005), El-Sawalhi and Mansour (2014)

2.3 Evaluation of the success of PPP projects

Evaluating the success of public works projects in traditional delivery approaches is fairly straightforward. However, establishing the explanatory factors that influence the success of public-private partnership projects is rather complex and challenging. The intrinsic problems in PPP evaluation mostly stem from the dynamic nature of the PPP process. PPPs are quite distinct from traditional delivery strategies due to the nature of their contractual relationships and long concession period. Evaluating PPPs is more difficult than traditional procurement due to complexity and broad risks involved in PPP (32). For instance, a typical traditionally procured project is regarded as successful or failed by examining its outputs and outcomes. The outputs-outcomes based evaluation allows policymakers to identify how policies and projects can be adjusted to attain their goals (33). However, measuring the success of public-private partnership projects using outcome-based indices is challenging due to reliance of such projects on tools that involve substantial interaction with multiple parties.

Similarly, the application of other traditional project evaluation techniques also seems to be quite inappropriate for evaluation of PPP projects. For instance, the conventional ex-post technique is widely questioned as not being sufficient enough to assess the successful implementation of PPP projects. The ex-post evaluation, which is product-oriented measurement, is carried out after project completion mainly for review purpose. For this reason, the method, cannot provide insight that adequately capture the dynamic nature of PPP project operations (34). Similarly, using the 'Iron Triangle' (35) time, cost and quality measures may not adequately reflect the exclusive success of PPP infrastructure development projects (36). For instance, the over-reliance on public sector comparator (PSC) technique, as a cost measure, in the

assessment of value for money (VfM) of PPP projects do not reflect the complexity of PPP procurement process (37).

To address the complex nature of public-private partnerships, (38) developed a key performance indicators model for measuring the success of PPP projects. However, (39) criticised the (38) model for its over-emphasis and limitation to only the 'partnership' phase of project development. The authors contended that the model ignored to measure "initiation and planning" and "procurement" phases which are equally important phases of PPP project development (40). Accordingly, (39) suggested the adoption of a comprehensive process-based evaluation framework that deals with the multiple stages and complexity in PPP. However, the (39) "process-based" framework is limited in application as no validation has been conducted to concretise its underlying hypothesis (40).

Borrowing from the arguments that success factors determine success of projects (41) and identification of success factors is key to achieving success of PPP projects (42), this article adopted SEM approach to evaluate the success of PPP projects in the study area. The approach involves evaluating the extent of contribution of the success factors in the overall success of PPP housing project in Nigeria. The approach evaluate the success of PPP projects across the multiple stages of partnership from project selection to contract management.

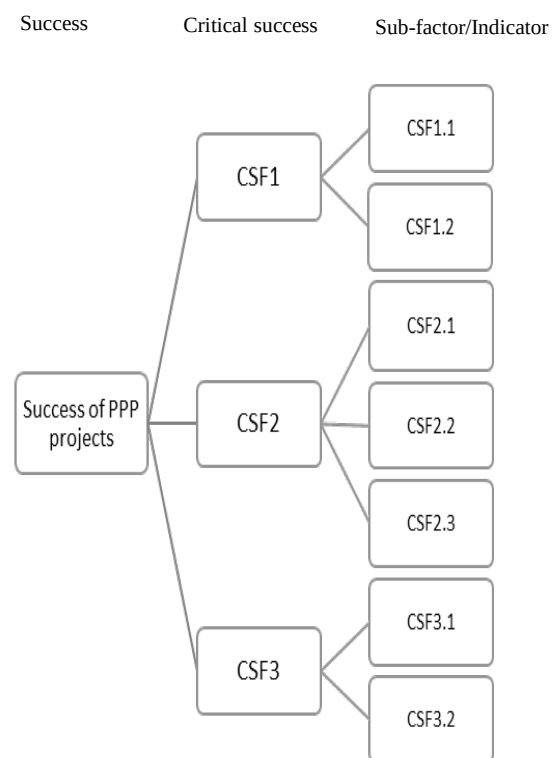
Research Methods

To achieve the objective of the study, a questionnaire survey was conducted with both the public and private sector participants who are the key stakeholders in the PPP project (43). The respondents were asked to rate, the extent of contribution of a list of CSFs gleaned from literature, in the success of a PPP housing project in the study area. The authors administered a total of four hundred (400) questionnaires. One hundred, and fifty-four questionnaires were returned indicating a reasonable response

rate of 38%. The data was analysed using structural equation model with the aid AMOS software.

Borrowing from the submission of (44) that success factors determine success and (45) that identification of success factors is key to achieving success of PPP projects, this article adopted a conceptual framework of evaluating the success of PPP projects (Fig 1).

Fig 1: A conceptual framework for evaluating PPP project success



From the review of literature, five categories of CSFs (latent constructs) each with a list of success sub-factors (indicators) are adopted for the survey (Table 2). The grouping of the factors into broad categories of CSFs shows the relationship among inter-related factors and concurs with similar categorization by (46) and (47) regarding the relevance of the CSFs. As (48) noted in their extensive literature review, these CSFs have received recognition due to the frequency of citation they received by various authors.

Table 2: critical success factors with a list of success sub-factors

Critical Success Factors	Success Sub-factors
Effective Procurement process (EPP)	Transparent procurement process (EPP1) Competitive procurement process (EPP2) Good governance (EPP3) Well-organized and committed public agency (EPP4) Trust and openness between parties (EPP5)
Appropriate risk allocation (ARA)	Equitable risk allocation in contractual agreement (ARA1) Equitable risk allocation in operational agreement (ARA2) Equitable risk allocation in loan agreement (ARA3) Equitable risk allocation in design/build contract agreement (ARA4)
Favourable investment environment (FIE)	Stable political system (FIE1) Favourable economic system (FIE2) Fair and efficient legal framework (FIE3) Availability of financial market (FIE4) Supportive and understanding community (FIE5)
Judicious Government control (JGC)	Government guarantee (JGC1) Efficient approval process (JGC2) Consistent monitoring (JGC3) Action against errant developers (JGC4)
Good Private Consortium	Technical competence (SPS1) Financial capability (SPS2) Rich experience in partnering (SPS3)

3. Analysis & Results

Two main steps in SEM involves first, confirming the validity of the indicators in measuring the latent variables and second, fitting the latent variables and indicators into the structural model to establish their relationship through path analysis (50). In SEM analysis, convergent validity and discriminant validity must also be achieved to the required level. While convergent validity measures the level of similarity among the items of a construct, discriminant validity seeks to measure the level of disparity between latent constructs. The discriminant validity is usually determined by a correlation value less than 0.90 and the average variance extraction (AVE) greater than the square of the correlation of the variables (51).

Following the steps in SEM, the internal reliability of the success sub-factors in measuring the CSFs was first measured through an exploratory factor analysis (EFA). The EFA results show that all the

latent constructs achieve internal reliability with a Cronbach's Alpha of greater than 0.700. Every measurement model involving latent constructs needs to undergo CFA before modelling into SEM. However, to avoid problems of model identification when CFA is done for every construct (52), the pooled CFA was carried out for the measurement model comprising of the five constructs namely efficient procurement process (EPP), appropriate risk allocation (ARA), favourable investment environment (FIE), judicious government control (JGC) and strong private sector (SPS).

The model statistics indicate that the initial model did not achieve a perfect fit. Accordingly, modification indices were checked to determine inconsistencies that led to bad model fit. The items EPP2, EPP5, ARA3, FIE1, JGC1, and JGC4, having exhibited low squared multiple correlations were deleted to improve goodness of model fit.

Similarly, modification indices shows that MI occurred between the error terms e13 and e11. Accordingly, the items FIE2 and FIE4, corresponding to the error terms were covaried to improve the model fitness. The final CFA model has shown that all the five constructs (EPP, ARA, FIE, JGC, and SPS) in the model have exhibited internal convergence based on the data captured for the study (Fig 2).

After the CFA model achieved goodness of fit, the model was examined to determine whether its variables achieve validity reliability measures. The results of the analysis show that sufficient validity holds because CR and AVE values are greater than 0.6 and 0.5 (52) respectively. Similarly discriminant validity holds as the correlations of variables shown in Figure 2 were below 0.85 (53, 54).

CFA was also carried out to evaluate the success of the PPP housing project as second order measurement model

comprising of the five first order unobserved constructs. As expected, the initial model, did not achieve the recommended values for GFI, AGFI, and TLI and it shows an insignificant p-value (0.000).

Figure 2: CFA model

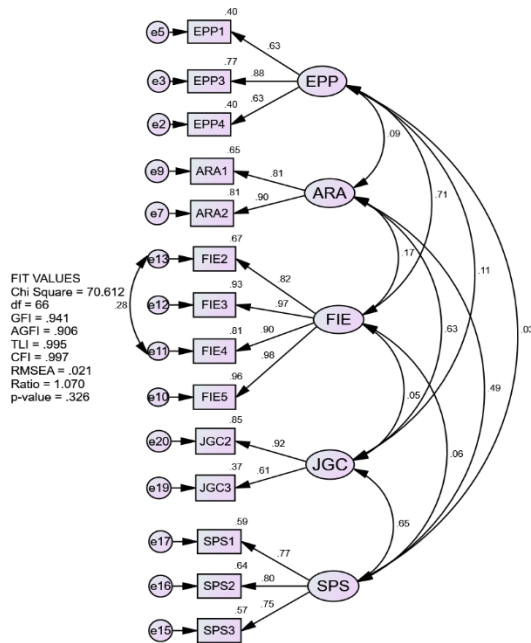
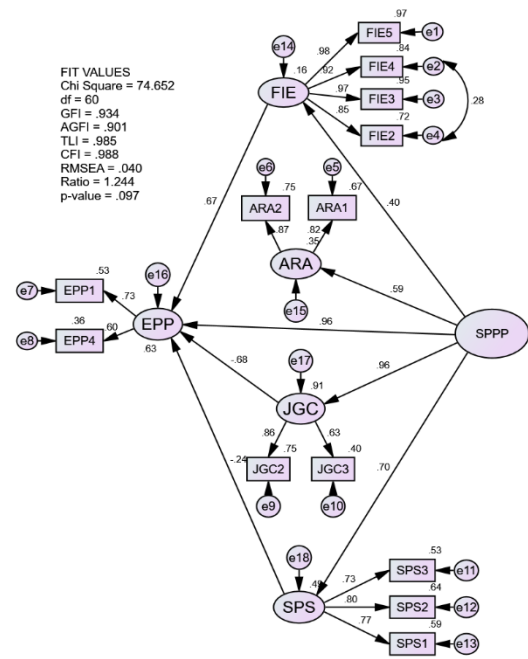


Figure 3: Final measurement model for PPP housing project success



Accordingly, the modification indices were checked to determine sources of bad fit. Modification indices (MI) occurred between e3 and e23 and the regression weight statistics show MI between FIE and EPP, JGC and EPP, SPP and EPP. Accordingly, item EPP3 (represented by error term e3) showing covariance with FIE (represented by error term e23) was deleted to achieve discriminant validity and improve model fit.

Also, the items FIE, JGC and SPS were correlated with EPP since the MI indicated a strong relationship between them. The re-specified model (Figure 3) shows significant improvement in which all the GOF indices fall within acceptable values.

4. Discussion & Conclusion

The CFA measurement model was examined to explore the contribution of the CSFs in the success of PPP project in Nigeria. The regression weights indicate the contribution of the CSFs on the success of PPP housing project in Table 3.

Table 3: The contribution of CSFs on the success of PPP Housing project

Parameter	Estimate	Lower	Upper	p
FIE <-- SPP - P	.401	.320	.476	.004
JGC <-- SPP - P	.955	.813	1.092	.004
SPS <-- SPP - P	.698	.560	.842	.004
EPP <-- SPP - P	.964	.672	1.434	.004
AR <-- SPP A - P	.593	.420	.726	.004
EPP <-- SPS -	-.245	-.631	.208	.251
EPP <-- FIE -	.675	.481	.879	.004
EPP <-- JGC -	-.678	-1.347	-.214	.011

Efficient procurement process (EPP) has the highest contribution indicating a standard deviation of 0.964 (96%) when the success of PPP project (SPPP) goes up by 1 standard deviation. On the other hand, favourable investment environment (FIE) has the lowest impact with a contribution of only 40% (0.401). The accepted (statistically fitted) model in figure 4 also indicated correlations between the CSFs (FIE, JGC, and SPS) and EPP in determining the success of the project. By implication, the model suggested that some form of mediation (indirect relationships) between the three CSFs and EPP in determining the success of the housing project. The results in Table 3 (shaded in yellow) indicates a negative but non-significant relationship between EPP and SPS (-2.45). However, the results show a significant relationship ($p < 0.05$) between EPP and FIE (0.67) but a negative correlation between JGC and EPP (-0.678).

The findings of the study revealed that the success of the PPP housing project is dictated by the complimentary influence of

the critical factors 'efficient procurement process', 'judicious government control' 'favourable investment environment', and 'appropriate risk allocation'. The authors, therefore, recommend that decision makers should always consider those key determinants of success in assessing the performance of PPP projects.

The authors conclude that although a list of factors may be identified as critical, the factors do not exist in isolation but also share complimentary influence on the success of the PPP projects. Accordingly, future research agendas may wish to focus on exploring the reasons interconnection of the multiple factors that influence the success of PPP projects in different administrative settings.

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PROPOSING ROBOTIC FOLDABLE HOUSES FOR A HALF-DAY URBAN LIFESTYLE

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Abstract

With the increasing cost living in the downtown, the issues from misdistribution of the accommodation and the work places for office workers become worse and worse. Linking together them can not only ease urban traffic congestion but also save much time for the office workers. By utilizing the vacant time of some public areas, this study proposes the robotic foldable houses for a half-day urban lifestyle. Based on the grounded theory, this study has outlined benefits from application of robotic foldable houses. Meantime, this study also sets the design requirements for the sample units by analyzing the characters. Finally, this study concludes with the good performance of the proposed units in sustainability, efficiency and effectiveness.

Keywords: *Robotic Folded House, Half-Day Lifestyle, Sustainability, Urban Design*

1. Introduction

Buildings have long been associated with unmovable and unfordable stereotypes. However, with the acceleration of city developing and population harvesting, the cost of living in downtown has been incessantly rising and the land use in the city central has been pushed to the edge of sacristy [1]. In addition, the narrow space and overpopulation in the downtown have resulted in the increasing travelling time and distance from one zone to another. Therefore, meeting the needs of metropolitans is perhaps the urgent application of a foldable building that can be quickly linked together the accommodation and the ephemeral communities. As a matter of fact, the central areas that are subjected to publicity such as squares, pedestrian zones, plazas, and so on, are normally fully utilized during the daytime but vacant at night. This fact highlights the possibility of operating such spaces as living environments during nighttime. This study proposes a new adaptable living lifestyle, the half-day

urban lifestyle, for metropolitans to accommodate arability. The theory is based on designing robotic foldable residential units to achieve spatial utilization as well as to contribute efficient lifestyle. The proposed units can be folded at daytime enabling normal business activities and erected automatically during nighttime when the business closed [2].

From the geospatial development point of view, the robotic foldable house is undoubtedly favoring the urban developing concept of mobility, foldability and flexibility. It is highlighted most that this type of building can not only be manufactured and placed in position quickly but can also perform its ability to fold and unfold automatically during its needs without making it cost too much. Moreover, by utilizing its advanced features, this type of building is so versatile that also can be used a mobile working station to cope with urgent circumstances such as urgent aids, earthquake rescuing and so on [3].

As the application of robotic foldable houses becomes popular to the public area design, the transformation from publicity into privacy and from normal business function to residential dwelling function is crucial. The building itself will be making no influence to the public activities in the daytime and maintain its accommodability to achieve this novel urban lifestyle in the nighttime. The proposed areas should be capable for accommodating a certain number of houses and making no influence to the existing commercial environment [4].

2. Research Methods

This study follows grounded principles to review relevant technologies in order to validate the proposed concept. Adaptable means of approaching this idea is determined using current knowledge of prefabricated houses and content analysis. The majority determinants from this approach can be revealed as followings.

1. The proposed area should be investigated in order to fulfill the architectural design requirements for the dimension of the houses which should be ensuring user-friendly and cost-effective. The architectural appearance of the whole units shall be well dedicated and integrated with the neighboring physical environment and bio-environment, in which, the foldable units aimed to create not only a novel living lifestyle but an adaptable scenic view within the neighborhood as well.
2. The environment of the neighbors such as the fabric of the buildings, the height, the orientation and other elements will be taken into account when approaching architectural and structural design for the sample units, to ensure architectural harmony within the neighborhood. The fabric design for the proposed units is crucial to achieve indoor thermal comfort that prompts living condition when the house is occupied. The orientation of the house is an important parameter that associates with illumination, taking advantage of valuable natural sunlight source as much as possible for solar power plant during the daytime. Meantime, carefully chose the area that could possibly be shaded by the erected structures.
3. The environment assessment should be taken into account during the processes of both pre-construction and post-construction. The commercial activities in daytime are much more important in this zone. Therefore, the proposed units will do no interruptions to the business activities. In response to that, the proposed units shall be in a better form that “hide” underground without making deterrent for people to access the main commercial building or plaza. Meantime, the feasibility investigation must be carried out to assess potential advantages and disadvantages. After construction, it is also a necessity to inspect whether there is a potential adverse impact on business activities.
4. The interior design of the sample units is vital to achieved better living environment. The parameters for the inner walls, the ventilation systems, and the interior facilities will be taken into consideration as the appearance of which is of favorable to be compelling to fit the surroundings.
5. Safety issues should be considered for designing the houses. The safety issues are more likely to occur during the nighttime. As the houses are designed for the night use, the safety cannot be emphasized more. Thus, a detailed design for the doors and windows toward a safer and cozy living environment should be involved.
6. Relevant robotic technologies and Building Information Modelling (BIM) techniques should be integrated for the proposition of the sample units. The 3D visualization is of great help to

the construction, operation and maintenance of the sample units. BIM technologies are applied to ensure the buildings is well tuned.

3. Analysis & Results

- a. The application of the proposed system is expected to diminish the research problem through the potential development of various advantages namely; formation of affordable robotic temporary housing, minimization of urban/suburban commutes/traffic congestion, decreasing environmental pollutions, and so on.
- b. The proposed foldable units are expected to be hidden underground during daytime and erected only during the night to prevent negative impacts on daily routine urban lifestyles during the daytime.
- c. The proposed foldable units are expected to be able to be erected automatically and close down for adjustable time settings to cater hassle-free implementation/automation.
- d. The folded houses are expected to be self-sustained.
- e. The proposed foldable units are expected to be straightforwardly mass-producible.

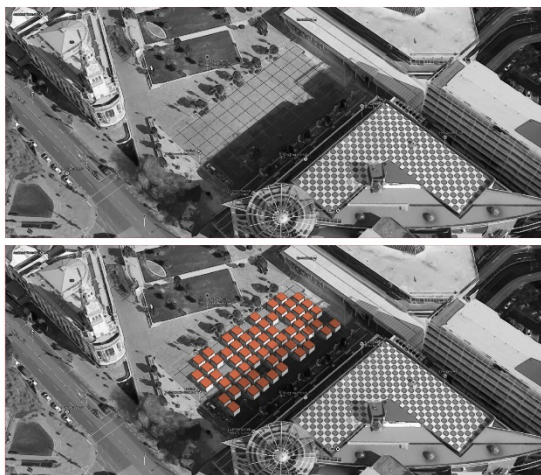


Figure 1 Robotic foldable houses (daytime/nighttime)

4. Discussion & Conclusion

Various advantages can be perceived as the result of applying the proposed system.

- a. The buildings will be made from green materials that can be recycled, biodegraded, or reused in other circumstances.
- b. The building is structural efficient and architectural aesthetic.
- c. The building is affordable and adaptable, providing indoor thermal comfort and safety. However, widespread application of the proposed units must be thoroughly investigated as an integrated part of urban nightscapes to minimize its potential social challenges.

The application of robotic foldable houses is sustainable because it not only has the potential to achieve the effectiveness of land use in the city center, but also delivers a half-way lifestyle for those who willing to adapt the easy way of accommodation without spending too much time on travelling and feel secured during occupancy. This application aimed at utilizing the land use in the urban area, absorbing the pressure from the metropolitans who stressed on accommodations and providing as much convenient living lifestyle as possible. The erected houses can be versatile in multiple applications in the future, and it can also be repositioned and environmentally friendly. The role of the robotic foldable houses is a prompted means to improve the efficiency, quality and environmental performance of downtown house use.

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INCLUSION OF WELL-BEING AND ECOLOGICAL VALUES IN GREEN BUILDING ASSESSMENT TOOLS

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Abstract

Many building sustainable rating tools rate the effectiveness of a building's contribution to a better world environment by measuring its performance in relation mostly to energy with additional emphasis in other aspects such as water, waste, indoor environment quality, transport, materials, and emissions. A simplified analysis is tabled to highlight the limited direct response of most green building rating tools to the health and well-being of building occupants. Inquiry into this deficit identifies a few salient points as a preamble to a larger discussion of use of rating tools to assess effectiveness of sustainability and the impact on ecology. Past notions of a sustainable planet resided in the making of sustainable buildings that reduced consumption of energy and other resources. The increased interest in creating healthier office environments as a sustainable action needs further analysis especially in relation to the ecological environment.

Keywords: Sustainability, Rating Tools, Health and Well-Being, Ecology, Biophilia

1. Introduction

In response to existing global issues of global warming and dwindling resources, many countries have advocated the use of a variety of green building assessment tools. Many of the more well-known ones such as LEED,[1] BREEAM [2] and LBC [3]; and others such as GBQA,[4] Green Mark [5] or GBI [6] measure the performance of the building with varying but usually more weighting towards efficiencies of energy, water usage and improved indoor environmental quality. To a lesser degree, some points are given over to ecological values and this might include the incorporation of vegetation within the building envelope. No direct points are given to design decisions made specifically for the health and well-being of the building occupants or the surrounding ecosystems or biodiversity of the locality of the building.

This short paper discusses the evolving trends in architectural discussion to include people and nature into the design of buildings and also points out some of the limitations that rating tools may have in relation to these two areas of concern.

2. Literature Review

There is a range of assessment tools for rating the sustainable performance of buildings or communities. Some academic articles illuminate the differences of several countries on an international level [7], [8] or within a single country [9] while others compare particular aspects such as social quality of the tool [10] or awareness of it.[11]

Growing interest in health, well-being and productivity in the workplace has generated the development of additional rating tools for the marketplace such as WELL Building Standard [12]; and guidance tools such as the '14 Patterns of Biophilic Design'[13]; and a Health, Wellbeing & Productivity in Offices report put out by the World Green Building Council.[14] Interest has also increased with use of the more demanding Living Building Challenge (LBC) rating tool.[3]

Generally, green rating tools (GRTs) assess a building's performance under the main categories of Energy, Water, Waste, Indoor Environmental Quality, Materials and can also include Transport, Emissions,

Management, or Ecology. Rarely does a green building rating tool specifically include health and well-being.

Janis Birkeland does not believe that the sustainability of a building can be fairly gauged with rating tools that use “linear-reductionist analyses”. She advocates a more innovative approach of using the idea of net positive systems to “create levers for biophysical improvements and social transformation at the ‘glocal’ scale.”.[15] Environmental regulation processes that do not include ethics or ecology tend to segregate nature from building design without contribution to the public good.

3. Research Methods

In relation to the limited intentions of this short paper, only an abbreviated comparison of selected rating tools for non-residential buildings is highlighted below. In addition, only the main titles obtained from the respective tools have been used for a quick glance for better understanding. Information about the GRTs were obtained online from the websites of the organisations.

Tool	Ecology	Well-Being	Energy
LEED - US Leadership in Energy and Environmental Design - US	Sustainable Sites	(indirectly affected through Air, Water and Light)	Y
BREEAM - UK Building Research Establishment Environmental Assessment Method	Land Use and Ecology	Items termed for Well-being are somewhat similar to IEQ items in other rating tools	Y
GBCA - Australia Green Building Council of Australia	Land Use and Ecology (with Ecological Value calculator)	(indirectly affected through IEQ)	Y
BCA GreenMark - Singapore Building and Construction Authority	(indirectly affected through Urban Harmony)	(indirectly affected through IEQ) with 2 pts for Well Being (Spatial Quality); and 2 pts for Social Benefits	Y
GBI - Malaysia Green Building Index	N	(indirectly affected through IEQ)	Y
LBC - US Living Building Challenge	Place	Health and Happiness; Equity; Beauty	Y
WELL - US WELL building standard for Offices	N	Nourishment; Fitness; Comfort; Mind (indirectly affected through Air and Light)	N
14 Patterns of Biophilic Design (guiding principles not a rating tool)	mainly using naturally occurring elements without overt engagement with ecosystem functions	Connecting with Nature in the space; Using natural analogues in design	N

4. Analysis & Results

Many assessment tools give predominant weightings to the reduction or more efficient consumption of energy, water and other material resources. Few incorporate benefits of increased local biodiversity or improved ecosystems near to the building.

For most green rating tools mentioned previously, the improved health and well-being of building occupants are usually addressed indirectly under items assessed in relation to indoor environmental quality such as air pollutants, mould, daylighting or electric lighting, noise levels or external views.

There are many drivers for increasing health and well-being in buildings. In its Health, Wellbeing & Productivity in Offices report, the World Green Building Council states that its ultimate aim is to enable “maximised return on investment for all strategies designed to benefit occupants and improve productivity”.[14] Some of these strategies include reduced employee absence costs, greater staff productivity, reduced occupant complaints, increased company revenue. By contrast, the philosophical framework for the LBC focuses on envisioning “a future that is socially just, culturally rich and ecologically restorative” through the generation of net positive conditions for water, energy, and waste that “work in harmony with... the site and its surroundings”.[3]

One would likely be correct in thinking that many of the items listed in these rating tools have already been practised by good architects where natural light is maximised or universal access provided for closer proximity to natural elements. What has not been done previously is to identify these design intentions as assessable items in relation to sustainable design.

5. Discussion & Conclusion

The explicit inclusion and expansion of health and well-being as assessable features in new green rating tools such as the WELL Building Standard is a recent development. The only building rating tool prior to WELL that has a more explicit emphasis on a healthy environment for people is the LBC which has been evolving since 2006. Currently, the LBC is the only rating tool that has a coordinated rating system of connecting the building to the larger landscape it is located within, through its format of “scale jumping”. This is a meaningful addition to the environmental tools discussion as it causes one to address the implications of building construction outside of its building footprint such as on-site biodiverse habitats and close-by ecosystem functions.

Additionally, the LBC requires the deliberate incorporation of nature within the designed lived spaces to provide for “sufficient and frequent human-nature interactions” and not just the provision of views. Due to public awareness, there is growing interest in the incorporation of biophilic elements in architecture. Although not a rating tool, the ‘14 Patterns of Biophilic Design’ is a guidance tool prepared by US environmental consulting firm Terrapin Bright Green to promote biophilic qualities in architectural design such as the use of visual and non-visual (haptic) connections with nature, and non-rhythmic sensory stimuli.

Desiring to include views or a more direct participation with nature is both relevant and laudable. However, this biophilic desire must be met in connection with its impact on the ecology. Our desire for a nice view of plants right outside our window should not come at great cost of increased potable water usage. Neither should our preference for a particular ‘natural’ look override existing locally functioning ecosystems, for example, the

use of large expanses of lawn over a less manicured patch of indigenous shrubs which is likely more biodiverse. Making ourselves feel better with views of nature may not benefit the very nature we say we love.

Setting a higher standard for addressing ecology and occupant well-being in architectural design is warranted. The difficulty might lie in the equitable measurement of these aspects since they are elements that function within an open rather than a closed loop system. However, this challenge must be met to assist in providing long-lasting sustainable outcomes.

In conclusion, green building assessment tools have been evolving in response to new knowledge and identified concerns for people as well as for the animal and vegetative environments. We are starting to realise that if we only concentrated on making buildings work more efficiently in terms of material resource consumption without paying just as much attention to the surrounding ecosystems that support our very existence, we will not go as far in addressing local or global environmental issues. Each one affects the other in deeper ways than originally thought or acknowledged. It is becoming apparent that we are all connected within a larger system whether ecologically or economically. Thus, as designers or policy makers, taking a step towards a more direct connection between building design and the way we can live within the built form as well as the natural ecosystem needs to be urgently considered.

We must put people and ecology back into the sustainability equation. As to how we do that “without ecological offense or the disadvantage of anyone”.[16] via current rating tools is a challenge that is worth debating and refining because what is at stake is the earth we all inhabit.

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EARLY MODERN APARTMENT FACADES IN KUALA LUMPUR: OVERALL THERMAL TRANSFER VALUE

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Abstract

The study dissects the impact of shading on the Overall Thermal Transfer Value (OTTV) through residential building facade with specific reference to the Early Modern apartment facade in Kuala Lumpur. Characterized by its modest mass-produced appearance to cater the low-income groups, special attention is given to the design of the extended open corridor system which becomes the pinnacle of solar shading manipulation on the apartment facade. The selected case study is the Melati Apartment, one of the earliest flats built in Kuala Lumpur, located off the Loke Yew Street. The amount of shading area (%) of the apartment façade is initially simulated and systematically recorded over the course of a day (8 am to 7 pm). While the study records variations in the shading areas alongside time in response to of the length, width and height of the fenestrations and the open corridor system, other parameters like façade orientation, temperature difference, U-values, absorptive factor, and shading coefficient remained empirically similar throughout the study. The procedure proceeds with the calculation of the OTTV which is meticulously undertaken under two different facade conditions which are the fully-exposed and the shaded façades. The study utilizes the subtraction method where the OTTV of the shaded facade is subtracted from the OTTV of the fully-exposed façade in search for OTTV reduction. The result reveals the time period from 11 am to 3pm culminates the highest shading area provided by the corridor, consequently resulting in the lowest OTTV of the residential façade. Conversely, it emerges that in the early morning (8am to 10 am) and late evening (5pm to 7pm) the OTTV of each facade reaches its highest point during the day due to less shading percentages during these hours. Further analysis unveils the open corridor system's capability to reduce nearly 50% of the average OTTV of the fully exposed façade through shading.

Keywords: High rise Apartments, Early Modern, OTTV, Kuala Lumpur

Introduction

The purpose of this study is to evaluate the Overall Thermal Transfer Value (OTTV) of the Early Modern apartment façade under the influence of different amount of shading at different times over the course of a day. A case study near Jalan Loke Yew in Kuala Lumpur is selected to carry out the study. The early modern apartment style is characterized by its purely simplistic geometric configurations with minimally adorned modular units that embolden its mass-production paragon. Each of these housing units is united by a set of open corridors adjoining to the stairs to vertically link the different levels of the apartment. The embodiment of the extended open corridor system inevitably provides the only opportunity as a shading device for the façade against direct solar radiation during

the daytime. Ultimately, it is detrimental for the building façade to be designed to provide energy efficient and thermally comfortable environmental conditions due to advance solar radiation in response to Malaysia's tropical climate [1].

To calibrate the building's envelope energy efficiency the study employs the principle of Overall Thermal Transfer Value (OTTV) in elucidating on the impact of solar radiation on primarily the apartment façade coupled with the impact of shading areas during specific times in a day [21]. Since its inauguration in 1980, the OTTV calculation method is adopted by several tropical countries in South East Asia including Thailand and Singapore, as a reference to calibrate the amount of thermal transfer values through building façades in

regulating thermal comfort alongside energy consumption [b]. Generally, the OTTV measures heat transfer through building envelope by three methods namely conduction through an opaque surface, conduction through glass window and solar radiation through glass window [22]. In Malaysia, the OTTV is dependent on four parameters which are Window-to-Wall Ratio (WWR), Shading Coefficient (SC), U-values and solar absorption (α) [2], with the recommended OTTV of less than 50 Wm^{-2} [3].

In order to understand the impact of shading generated by the corridor system on the OTTV of the building façade, the study proposes critical analysis of the façade in two stages. The first stage is to carry out the sun shading analysis to measure the percentage of shaded areas (%) respective to the overall façade composition over the course of a daytime. The façade will be simulated from the time period of 8 a.m. to 7 p.m. and the amount of shaded areas for every hour is systematically recorded. The changes in the façade WWR for each hour according to its respective shading percentages will be calculated and recorded during this stage. The second stage is followed by the OTTV calculation of the apartment façade which will be approached in two different façade conditions which are the fully-exposed and the shaded façades. The process continues with the subtraction method where the OTTV of the shaded façade is subtracted from the OTTV of the fully exposed façade to observe the amount of OTTV reduction to be achieved by the open corridor system as the only source of shading device for the early modern apartment.

The findings of this study will provide incisive insights on the importance of shading in controlling the thermal transfer through building envelope to maintain thermal comfort and energy efficiency.

Selected Case Studies

In this study, an apartment which embodies the façade design reminiscent to the typical early modern architectural style was selected as a case study. The style is characterized by an embodiment of simple geometrical forms and unornamented design aiming at amplifying the modernist conception of 'less is more'. The construction utilizes an amalgamation of concrete space-frame structures, brick walls and cement render finishes. Historically, the first high-rise apartment built in this fashion is the Sulaiman Courts a year before the independence in Kuala Lumpur. A few years following its construction, the government decided to build the second apartment known as Pekeliling Flats in 1964.

The Early modern architecture became the popular style particularly in Malaysia from the 1950s to 1970s (Figure 1) where several apartments which manifest the style began to be massively constructed up to the early 1980s. It was during this time that the government was actively constructing low-cost apartments to accommodate the low-income families who lived in squatter homes under a relocation program envisioning towards 'Zero Squatter' policy in Kuala Lumpur [4]. Simultaneously, the word 'flat' was infamous in drawing reference to apartment building.

Today, this word is minimally utilized and it was replaced with the term 'apartment'. The early modern style commonly employed the mass-production construction techniques, typically distinguishable by the design of modular and standardized apartment units. The technique has remarkably expedited the construction process to address housing shortages in Kuala Lumpur [5]. Ultimately, the high rise apartments became an alternative in provision of house units for the low-income earners as their intrinsic shelter [6].



Figure 1: Sri Perak Flat in Sentul, Kuala Lumpur.

The style especially parallels mass-production and rapid construction concepts further enhanced by technological advancement. The *mélange* often results in simple composition resorting to basic geometric shapes like square, rectangle and circle to illustrate standardized modular house units in design coupled with production process of working drawings to submit for the local authority's approval. In consequence, the design over-simplicity has undeniably hastened the entire progress [7], [8], [9].

In the early modern period, the apartments were typically incorporated with open corridor system at the front facade. The extended corridor serves as the access pathway for the users and residents to connect with the entrance door of the apartment unit. The design was inaugurated by the British Administration slightly before the country's independence which later shapes the development in the apartments' style.

The style characteristically bears the influence from infamous modernist architects during Industrial Revolution in Europe like Le Corbusier, Mies Van der Rohe and Walter Gropius in building high rise flats for laborers, with the use of elevator embedded in the building design [10], [11], [12]. The open corridor system

became the popular signature for the design of apartments such as Flat Isokon built in 1932 in Hampstead, London [13]. Reinforced concrete structures with brick walls, wooden frame for doors and glass louver windows were the ideal construction materials and the apartments were often finally crowned with either flat or nearly flat roof.

The federal government projects on high-rise apartments are mostly concentrated in the capital city of Kuala Lumpur due to the lack of available lands. According to data from the Department of Statistics Malaysia [14], apartment units accounted for the largest percentage of all house types with 73% apartments are located in Putrajaya, the new administrative city for the federal government of Malaysia. The number of apartment units has overshadowed the number of terrace house types as the government is in favor of building high-rise apartments, enabling them to supply hundreds of house units per hectare to address the high demand as a direct result of population booming. By the year 2000, slightly over 2 million people were recorded to have lived in high rise apartments in Malaysia [14].

The Melati Apartment which is located in Pudu area in the city of Kuala Lumpur is selected for the case study. It is known to be amongst the earliest apartments built in this city similar to the Sulaiman Court apartment. The first apartment to be constructed in Pudu area was completed in 1958, while the last was completed in 1965. Figure 2 illustrates the apartments designed from 15 to 18 stories in Loke Yew Road. The location of the apartments in this study is the Melati Apartment (Figure 1) at Loke Yew Road, also referred to as the Loke Yew Apartment



Figure 2: Melati flats at Loke Yew Road in Pudu area.

The study focuses on analyzing the impact of shading performance provided by the open corridor system on the thermal transfer process on the apartment facades. Figure 3-5 illustrate foundation to roof detail of the front apartment façade drawn at the initial stage used for the building simulation. The detail was drawn at a sectional cut of the corridor and recessed wall with window location.

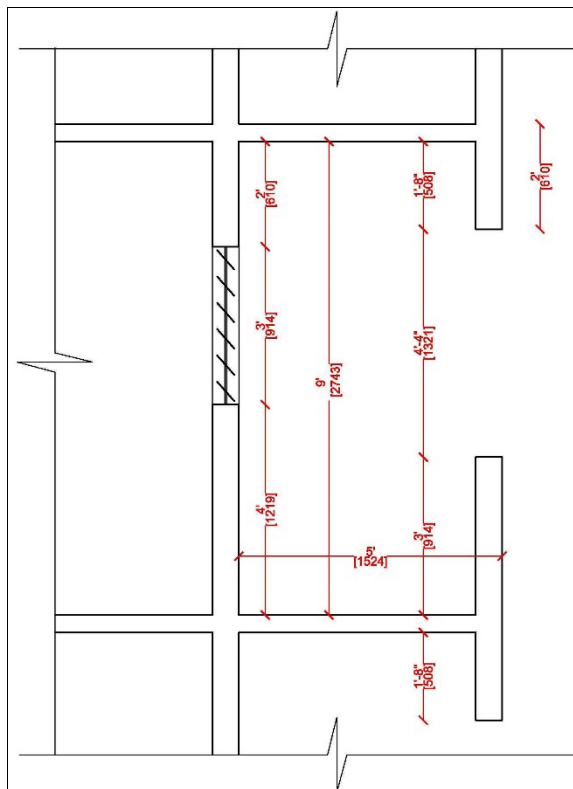


Figure 3: Foundation to roof detail of Melati Apartment.

Research Methodology

The study started by evaluating the shading areas (%) of each of the apartment facades during daytime (from 8 am till 7 pm) over the course of a day. This is carried out through a computer simulation to analyze the intensities of shading areas provided by the open corridor system on the apartment façade. The result of the simulated façade and the amount of shading areas is recorded as shown in table 1.

Table 1: Percentage of Shading Areas at different times during a typical daytime

Time	Shading area (%)
8 am	53
9 am	54
10 am	67
11 am	100
12 pm	100
1 pm	100
2 pm	100
3 pm	100
4 pm	87
5 pm	58
6 pm	54
7 pm	53
Average	77

Since the façade of each of the apartments invariably received mixed percentages of shades over the day due to the presence of the open corridor, the impact of shading on the OTTV through the building has to be considered.

Firstly, the OTTV of the façade in each apartment with 100 per cent exposure to solar radiation is calculated using the following formula set by the Malaysian Standards (MS 1525:2007):

$$\text{OTTV}_w = 15 \times \alpha \times (1 - \text{WWR}) \times U_w + 6 \times \text{WWR} \times U_f + 194 \times \text{WWR} \times \text{SC} \times \text{CF} \quad (1)$$

α = Solar absorption factor of a wall

U_w = U value of the opaque part of the wall (W/m^2k)

U_f = U value of the fenestration (W/m^2k)

SC = Shading Coefficient of window

CF = Solar Correction Factor

The absorption factor of a wall α indicates the propensity of a wall to absorb solar energy. For this study, the selected value of α of the brick wall is 0.75 [15]. While SC is defined as the shading coefficient of a fenestration specifically referred to as the ratio of solar heat gain through a particular glass type compared to the solar heat gain through a 3mm clear float glass. The study suggests the proper value of SC chosen is 0.95.

The values yield from this method representing the OTTV of each of the apartment facades without the presence of shading device. To elucidate the extent of shading on OTTV of these facades, further calculation is required by substituting the OTTV parameters that are directly intertwined with shading areas.

The façade orientation selected for the OTTV calculation is based on the facade which receives profound exposure to solar radiation due to its dominant gross wall areas. For Malaysia's geographic location and tropical climate, the West orientation is the predominantly associated with the highest propensity to solar exposure and radiation [16]. Therefore, only the West façade of the apartments is considered for the OTTV calculation to study the impact of shading percentages in mitigating thermal transfer into the apartment facades which contributes to the value of CF equalsto 0.94. Window-to- wall ratio WWR is the ratio of window area (glass and frame) to gross wall area [2].

$$WWR = \frac{A_f}{A_i} \quad (2)$$

A_i Total gross area of a wall, m^2

A_f Total gross area of a window, m^2

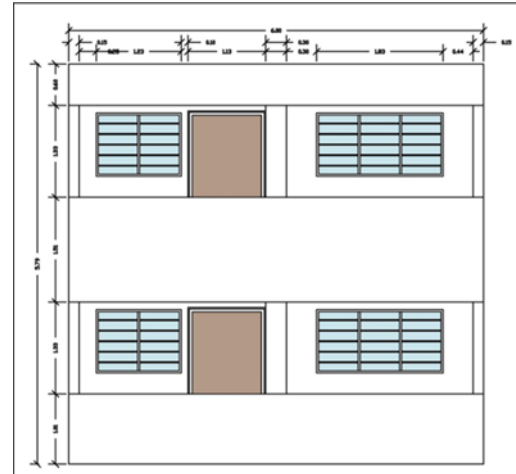


Figure 4: The façade of the Melati Apartment

For the apartment façade the fully exposed WWR is 0.32. The OTTV calculation of the fully exposed façade (100% solar radiation) is shown below:

$$OTTV_w = 15 \times 0.75 \times (1 - 0.320) \times 3.42 + 6 \times 0.320 \times 6.4 + 194 \times 0.320 \times 0.95 \times 0.94 = 93.88 \text{ } Wm^{-2}$$

Secondly, the OTTV calculation is repeated for each of the time period from 8am to 7pm to include the solar shading effects on the OTTV of the façade. Theoretically, the OTTV quantifies heat transfer through building envelope precisely driven by conduction through an opaque surface, conduction through glass window and solar radiation through glass window [24]. Without the presence of direct solar radiation, the thermal transfer process ceases to exist. As a result, only areas that are exposed to solar radiation is considered in the calculation of the WWR. Since the façade of the apartment is subjected to different propensities of shading during daytime the WWR which is a parameter in OTTV calculation is determined according to its respective time period.

To calculate the OTTV of the unshaded areas during the time period from 8am to 7pm, the WWR is re-calculated without taking into consideration the percentage of the shaded areas during these respective

times. This is due to the fact that shading alters the WWR by lowering the gross façade areas exposed to the solar radiation. Therefore, only the areas that are fully exposed to solar radiation is included to calculate the new WWR of the shaded facades of the apartments to quantify the OTTV of these shaded facades at different time periods in the course of a day. The different percentages of shading area provides the extent on the amount of shading that covers the façade which is determined through the shadow heights on the wall. The increase in shading area percentage means more areas are shaded from the upper part to the lower part of the façade as the sun angle rises.

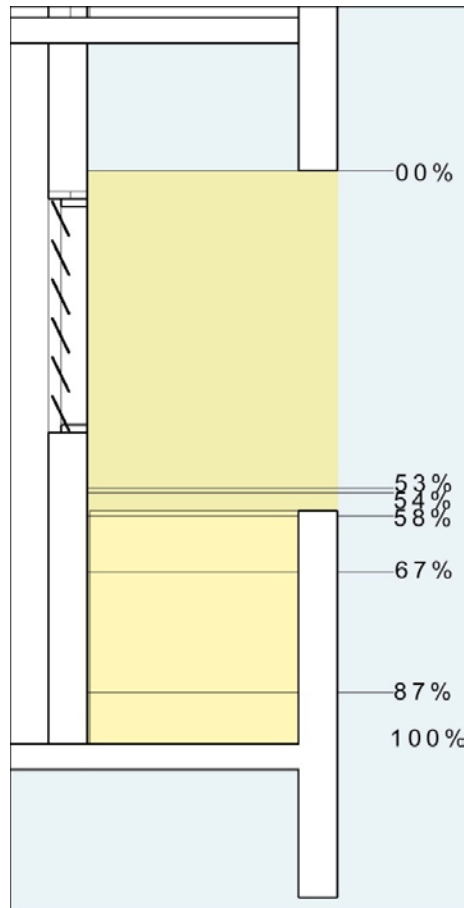


Figure 5: Shadow heights and shading percentages

The shadow heights represent the areas that are shaded in the façade which is crucial in WWR calculation as it only counts the area

that are directly exposed to solar radiation. Ultimately, only the unshaded window and wall areas are utilized in WWR calculation. The values of WWR of the shaded façade areas at different time periods over the course of a day are shown in the table below.

Table 2: Re-calculated Window to Wall Ratio according to shading percentages at different time frames

Time	WWR of Shaded Facade
8 am	0.08
9 am	0.08
10 am	0.05
11 am	0.00
12 pm	0.00
1 pm	0.00
2 pm	0.00
3 pm	0.00
4 pm	0.02
5 pm	0.07
6 pm	0.08
7 pm	0.08
Average	0.03

Each of the newly calculated WWR values of the shaded façade is substituted into the equation to obtain the OTTV inclusive of the impact of shading on the apartment façade at different times in a day which is shown in the table below.

Table 3: The OTTV of shaded façade at different hours from 8 am to 7 pm.

Time	OTTV(shading area)
8 am	52.33
9 am	52.33
10 am	47.13
11 am	00.00
12 pm	00.00
1 pm	00.00
2 pm	00.00
3 pm	00.00
4 pm	41.94
5 pm	50.60
6 pm	52.33
7 pm	52.33
Average	43.67

In providing further understanding on the extent of the open corridor system in providing shade against the solar exposure, each of the OTTV of the shaded area is substituted from the OTTV of the fully exposed façade calculated earlier which gives the value of 93.88 Wm^{-2} . The repercussion of this carrying out this method yields the OTTV reduction values of each time period.

Analyses and Findings

The analysis discovered that the 'open corridor system' is a typical design element in the early modern style apartments [17]. These corridors function as the main circulation system for the residents and users to get access to the entrance door of their apartment unit for each separate floor levels. The corridors mark the frontage of the apartment façade. The apartments constructed from the 1950s to 1980s were designed to accommodate the low-income groups and their family who had migrated from mostly the suburbs to the capital city of Kuala Lumpur in search for a new workplace.

These apartments were also referred to as 'the worker's house' [17], [18] and these buildings were previously known as 'flats'. The dimensions of these low-cost apartments were completely set to the most minimal to meet the standards of living required by the Municipal Council. In the case study, the apartment has the corridor's width of 4 to 5 feet which create a recessed wall of the apartment units with the variable heights ranging from $8\frac{1}{2}$ to $9\frac{1}{2}$ feet. The corridors have 3 feet height brick railing fence wall that serves as a railing. The extended parapet wall of the apartment below the brick railing fence at is set at 1 feet 8 inches.



Figure 6: Frosted Glass Louvered Windows

In this country, the standard brick wall is constructed to be $\frac{1}{2}$ feet or 6 inches wide. Each apartment unit has 20 feet wide façade front wall with a series of glass louver window (Frosted Glass Louvered Windows type – Fig. 6) and one entrance door. The front wall of the Melati Apartment has 4 feet high window sill alongside 3 feet high windows.



Figure 7: Melati/Loke Yew Flat (Example windows)

The study started by evaluating the shading areas (%) of each of the apartment facades during daytime (from 8 am till 7 pm) over the course of a day. The result is summarized as shown in the table.

Table 4: The OTTV of shaded façade and OTTV reduction values according to the percentage of shaded areas at different hours from 8 am to 7 pm.

Time	OTTV of shaded facade	OTTV Reduction	% Reduction
8 am	52.33	41.55	44.3
9 am	52.33	41.55	44.3
10 am	47.13	46.75	49.8
11 am	00.00	93.88	100.0
12 pm	00.00	93.88	100.0
1 pm	00.00	93.88	100.0
2 pm	00.00	93.88	100.0
3 pm	00.00	93.88	100.0
4 pm	41.94	51.94	55.3
5 pm	50.60	43.28	46.1
6 pm	52.33	41.55	44.3
7 pm	52.33	41.55	44.3
Average	43.67	50.21	53.5

The results pinpoint the relationship between shading and the OTTV of different facades of the early modern apartment styles in Kuala Lumpur. It can be observed from the table above the OTTV varies with the presence of shaded areas at different times contribute to varying average OTTV reductions of the apartment facade.

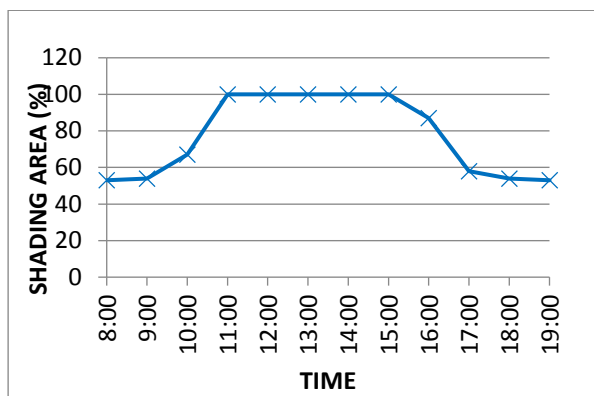


Figure 8: Percentage of Shaded areas at different times during daytime

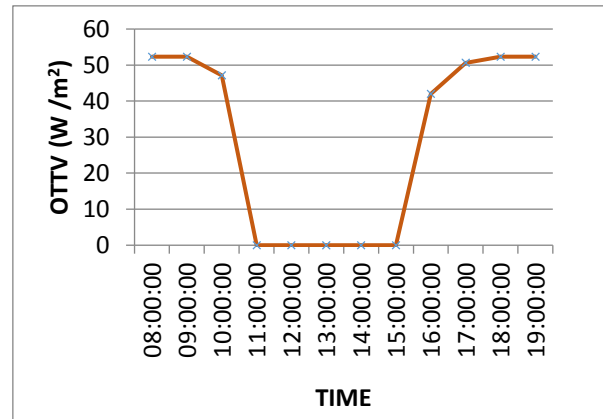


Figure 9: OTTV of shaded façade at different times during daytime

The result highlights the importance of shading in OTTV reduction for the early modern apartment façade. This is evident from the table where at the time period between 11 am to 3 pm the façade culminates the highest shading percentage of 100 %. This condition completely prevents direct exposure to daylight and consequently resulted in OTTV of 0 Wm^{-2} inducing a total of 100 % for the OTTV reduction value. This is due to the fact that OTTV is a process which takes place with the presence of solar exposure on the wall of the façade. Increase in daylight contributes to the increase of solar heat gain and the OTTV [19]. Without solar exposure the process of thermal transfer through the façade wall and fenestrations could not be determined.

A stark contrast can be observed in the OTTV values for the time period between 8 am to 9 am alongside 5 pm to 7pm. During these times of the day, the OTTV of the façade recorded the highest values of approximately more than 50 Wm^{-2} . Although the OTTV reached the highest during these hours, the values are still within the acceptable residential OTTV range suggested by previous study ranging from 35 Wm^{-2} to 65 Wm^{-2} [2]. This is apparently due to the smaller percentage of shading areas received by the façade at these times of the day. The reason is partly due to the low sun angle during these hours

coupled with the absence of vertical shading device [20].

Further stipulation on the average OTTV generated inclusive with the average shading percentage during daytime, the value of 43.67 Wm^{-2} is achieved. The average OTTV is surely within the comfortable range set by the Malaysian Standards (MS 1525:2007) of less than 50 Wm^{-2} . The average OTTV reduction capability of the open corridor shading system which is 50.21 Wm^{-2} reduces 53.5 % from the OTTV of the fully exposed façade of 93.88 Wm^{-2} , a percentage which reduces more than half of the original OTTV. The shading strategy provided by open corridor system outshines the capability of self-shading strategy which could only reduce 41.37 Wm^{-2} [3].

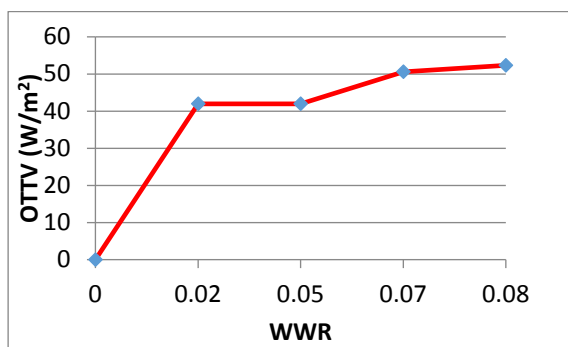


Figure 10 : OTTV at different WWR values

In retrospect, the finding underscores a profound relationship between shading and the value of WWR as a parameter in OTTV calculation. As the value of WWR progresses, the amount of OTTV gradually escalates depending on the amount of shaded area that covers the façade of the apartment. In order to satisfy the requirement set by the Malaysian Standards (MS 1525:2007), the study suggests the maximum value of 0.08 for WWR in order to achieve the requirement of OTTV less than 50 Wm^{-2} . The suggestion on WWR provided by the study seems to echo previous study which suggested the

recommended WWR range is between 0.01 and 0.18 for residential buildings [2].

Conclusion

In conclusion, the study underlines the importance of shading device in mitigating the direct exposure of solar radiation consequently contributing to reduction in OTTV through building envelope. The presence of the open corridor system incorporated in the design of the early modern apartment design substantiates the amount of shading during daytime in order to meet the OTTV requirement set by the standards. Although the average OTTV of the apartment satisfies the requirement, further measures to minimize solar exposure during early morning and late evening hours which include a vertical shading device could be considered in future designs to block the low angle solar radiation [20]. Additionally, the finding reveals the efficiency of the open corridor system as a shading device capable in lowering WWR to achieve the acceptable OTTV set by Malaysian Standards of 50 Wm^{-2} . Therefore, a combination of efficient shading device and thoughtful selection of WWR must be considered as guiding principles by architects in the provision of comfortable and energy efficient façade design in the future.

Acknowledgement

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SUNLIGHT PENETRATION EXTENT STUDY ON TWO EARLY MODERN HIGH RISE BUILDINGS IN KUALA LUMPUR

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Abstract

The study aims to analyze and compare the sunlight penetration extent for two buildings in Kuala Lumpur with early modern architectural style. The early modern style was popular for residential building in Malaysia during the 1950s to 1970s, and it was the solution for the government in order to provide the maximum number of units to people who moved to live in the major cities at that time. Two early modern residential apartment buildings in Kuala Lumpur were selected to be the case studies of this research, the buildings namely Sri Kelantan and Sri Perak. In order to get the sunlight penetration extent SunTool software were used to conduct the simulation hourly from 8:00 am until 7:00 pm. The findings show that the early modern style was able to provide good shading performance, the corridor and the façade design were able to prevent the unnecessary sunlight to penetrate into the house.

Keywords: Sunlight Penetration, High-rise Building, Early Modern Style, SunTool software, Kuala Lumpur.

1. Introduction

The aim of this research is to analyze and study the performance of façade shading design and the sunlight penetration extent of selected buildings in Kuala Lumpur with early modern architectural style. The study tries to focus on the high-rise apartments buildings because of the necessity of this type of buildings in the current life in a country like Malaysia. High rise apartments are multi-stories buildings serviced with elevators [1, 2]. The first high rise building was built in the United State of America in 1930s, and then in 1950s it was found in the United Kingdom, while in Malaysia Suliman Court apartment is considered as the first high-rise building in 1954. Then the high-rise buildings became popular in Malaysia during the 1970s [3], and now high-rise apartments are popularly used in provide a large numbers of apartment units urban area.

[4]. A survey by the Malaysian Statistic Department in 2010 shows that about 20 percent of the total house type in Malaysia

Were high-rise (apartment, flat or condominium) as shown in Figure 1.

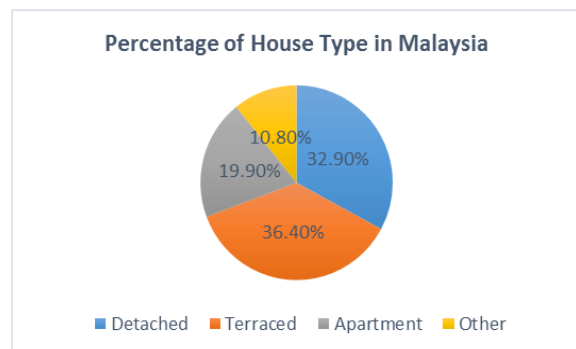


Figure 1. Apartments (apartment/flat/condo) percent 19.9% of the total house type [1].

The early modern architectural style was popularly used between 1950s to 1970s, this type of apartment were the solution of the housing shortage in the country which happened due to the migration from rural areas to the major cities by using mass-production to provide the big demanded number of houses to accommodate more families in the new cities [5, 6]. The architecture style design was simple and focus on the module units, straight lines

and corridor entrance system which go along with rapid technological advancement in the apartment design and increase the production efficiency [7, 8]. Figures 2 show example of the early modern style with simplicity in the colors, design, and construction materials which basically were: bricks, wooden frame glass window, and concrete. The roof design in the early modern style was nearly flat roof with modern construction design.

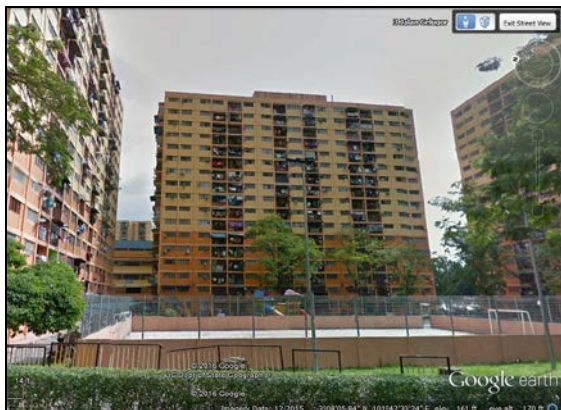


Figure 2. Sri Selangor at Gelugor Road with early modern architectural style.
(Source Google earth street view)

The study aims to provide a better understanding of the performance of façade shading design. Good façade shading design could be the best solution to overcome the problem of heat gain and reduce the energy consumption from the mechanical air conditionings. The good façade design helps to prevent the penetration of the unnecessary sun radiations into the house [9], in other words, the good passive design tries to apply the best shading devices to reach to the comfortable indoor atmosphere level with good daylighting [10].

2. Selected Case Studies

Two apartment buildings with early modern architectural style were selected as the case studies of this research, the two selected building designed with classic early modern features such as using brick walls, reinforce concrete for construction,

corridor entrance system and simple façade design with cement render finishes.

The apartments with open corridor entrance system at the front facade were a very typical design during the early modern period. The corridor functions as accessibility route for the residents to reach their unit's door [11, 12].

The two selected buildings for the computer simulations are located in Sentul, Kuala Lumpur. The first case study is Sri Perak apartment which is located at Jalan 14/484, Bandar Baru Sentul (Figure3 and 4). On the other hand, the second case study is Sri Kelantan apartment located at Jalan Sentul (Figure 5 and 6). Both of the selected case studies are considered from the earliest apartments buildings in Kuala Lumpur.

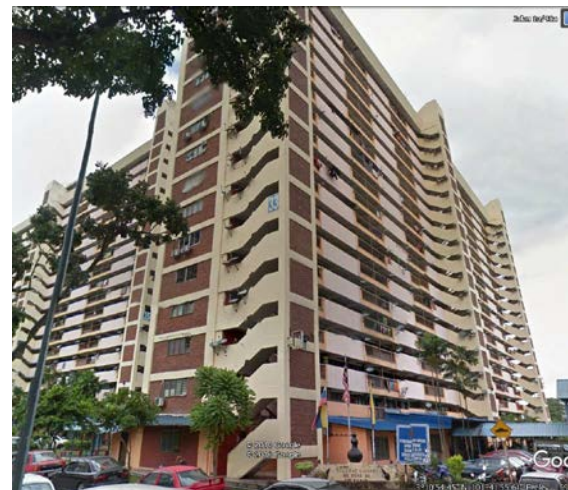


Figure 3. Sri Perak apartment at Sentul, Kuala Lumpur.
(Source Google earth street view)

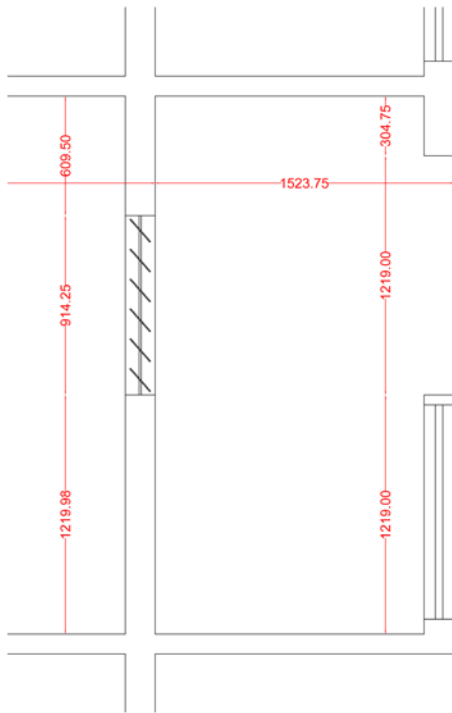


Fig. 4 Façade section of Sri Perak Apartment.



**Figure 5 Sri Kelantan apartment at Sentul, Kuala Lumpur.
(Source Google earth street view)**

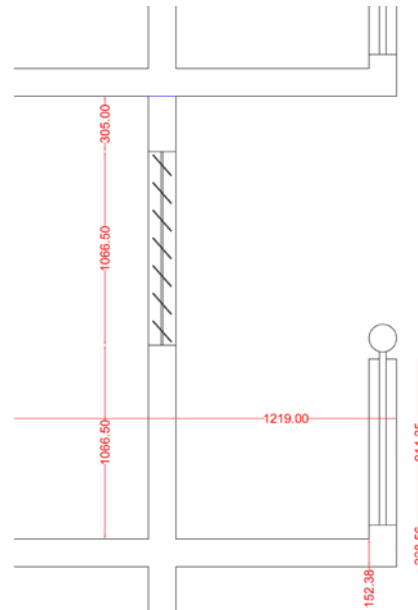


Figure 6. Façade section of Sri Kelantan Apartment.

3. Research Methodology

The goal of this research is to simulate and then analyses the direct sunlight penetration extent from the front façade of the two selected case studies, after that compare the results between the two front façade of the selected early modern architectural style buildings. The study uses SunTool Software to conduct the sunlight penetration simulation hourly from 8:00 am until 7:00 pm. The hourly computer simulation will be done when the sun-rays are perpendicular to the east building's façade from 8:00 pm until 1:00 pm and the west building's façade from 2:00 pm until 7:00 pm as in average the sun rises at 7:20 am and sets around 7:25 pm in March where most simulation will be conducted. The sun orientation and azimuth data which are provided in Table 1 and Figure 7 will be keyed into the software in order to ensure that the façade are exposed to the maximum amount of the direct sunlight at the simulation hours in both east and west façade [13, 14]. In order to get the maximum direct and perpendicular sun-rays to the case studies' façade, the study will be limited to east façade (90°) or west (270°) orientation¹¹, but in order to get the sun-rays perpendicular to the building's façade, the

azimuth will not always be 90 and 270, some small changes could be applied on the azimuth as shown in Table 1[15].

Table 1. Date, time, and azimuth of the sun when the sunlight extent penetration of façade was calculated for cases in Malaysia.

Orientation	Time	Date	Azimuth
East 90°	8:00 am	23 March	90°
	9:00 am	25 March	90°
	10:00 am	27 March	89.8°
	11:00 am	28 March	90.1°
	12:00 pm	29 March	90°
	1:00 am	29 March	92.2°
West 270°	2:00 am	16 September	90.5°
	3:00 am	29 March	89.8°
	4:00 am	18 September	89.8°
	5:00 pm	26 March	89.9°
	6:00 pm	24 March	89.9°
	7:00 pm	22 March	89.9°

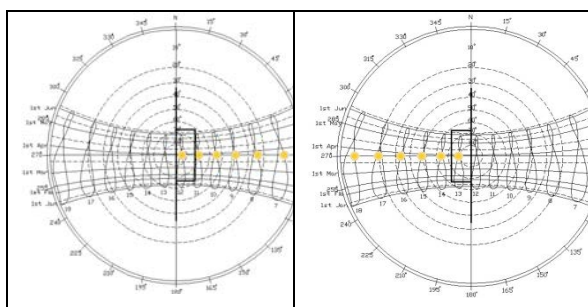


Fig 7. Sun path diagram shows the position of the sun perpendicular to the apartment facade from 8 am to 1 pm at the orientation of 90° (left) and from 2 pm to 7 pm at the orientation of 270° (right). Source: SunTool Software [14, 16]

After keying all the data of the orientation, time, and dates into SunTool software in order to do the simulation the façade section information and dimension will be keyed into the software as well, then SunTool will be able to simulate and provide all required results hourly from 8:00 am to 7:00 pm of all selected case studies [17] (Figure 8)

Since the SunTool software is limited to few façade section types, the results figures will be imported into AutoCAD in order to draw the missing parts and to get the final result of and overcome the software limitation problem. Figure 9.

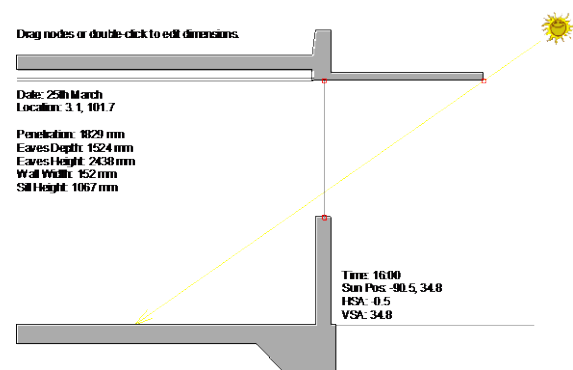


Fig 8 Example of the simulation window using SunTool program.

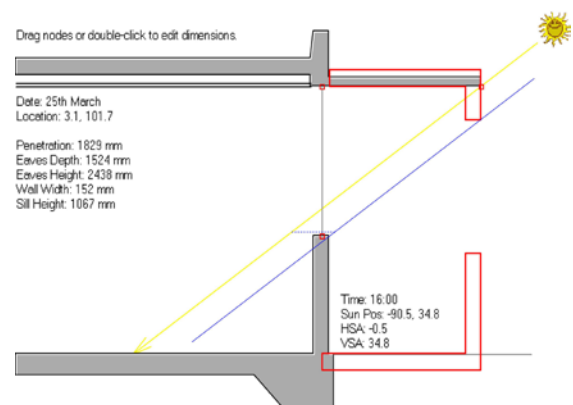


Fig 9 adding the missing Part of the section.

4. Analysis & Results

The results of simulation are shown in Table 2 and Figure 10. The results were taken hourly from 8:00 am to 7:00 pm in

all of the three case studies as mentioned earlier in the methodology.

Table 2. The extent of sunlight penetration from the building simulation.

Sunlight Extent Penetration		
Time	Sri Perak	Sri Kelantan
8:00 AM	11650	11678
9:00 AM	3503	3802
10:00 AM	0	1512
11:00 AM	0	0
12:00 PM	0	0
1:00 PM	0	0
2:00 PM	0	0
3:00 PM	0	0
4:00 PM	0	0
5:00 PM	1841	2134
6:00 PM	5117	5386
7:00 PM	25046	24941

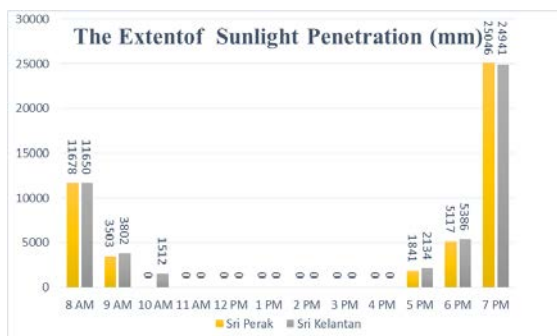


Figure 10. Line chart graph which shows the sunlight penetration extent of the two case studies.

The results in Table 2 show that in Sri Perak apartment the sunlight penetration starts with 11791 mm at 8:00 am and 3503 mm at 9:00 am, the façade shows an excellent shading performance with no any sunlight penetration from 1:00 a until 4:00 pm. Then the evening hours show some sunlight penetration at 5:00 and 6:00 pm with 1841 and 5117 mm respectively. The last hour of the simulations shows the maximum extent of sunlight penetration with 27083 mm.

On the other hand in Sri Kelantan apartment

5. Discussion

The study results and discussion of the sunlight penetrations extent find the followings:

- The two case studies have the similar behavior of shading performance at most of the day hours.
- Sri Perak Façade design shows great shading performance from 10:00 am to 5:00 pm with preventing all the sun rays from penetrating into the unit and show zero sunlight penetration. While Sri Kelantan shows the same from 11:00 am until 4:00 pm.
- The maximum sunlight penetration in Sri Perak apartment is 25046 mm while in Sri Kelantan is 24941 at the last hour of the simulation 7:00pm.
- At 8:00 am Sri Perak and Sri Kelantan have almost the same extent of sunlight penetration with 11678 and 11650 mm for Sri Perak and Sri Kelantan in order.
- At 9:00 am when the sun start rising up, Sri Kelantan has longer extent of sunlight penetration with 3802 mm and 3523 for Sri Perak.
- The next simulation hour show only minimal penetration of sunlight for Sri Kelantan with 1512 mm, with 0 mm for Sri Perak.
- In the evening at 5:00 and 6:00 pm the results show the sunlight penetration with 1841 and 5117 mm in Sri Perak and 2134 and 5386 mm in Sri Kelantan Façade respectively.
- The last hour of the simulation shows the maximum extent of sunlight penetration in both case studies due to the very low angle of the sun at 7:00 pm with 25046 and 24941 mm at Sri Perak and Sri Kelantan in order.
- The early modern style provided better shading performance than a neo-minimalist and colonial buidings which was simulated in previous researchs for Yasser Arab 2015 and 2016 as shown in Figures 11 and 12.

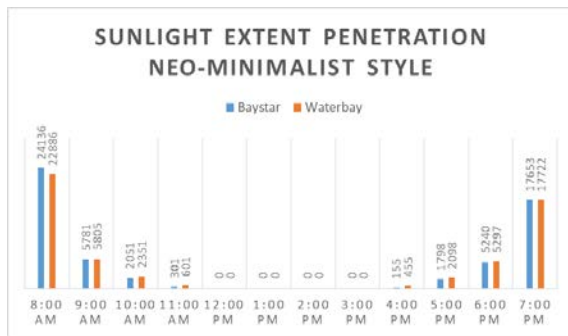


Figure 11 Line chart graph shows the sunlight penetration extent of neo-minimalist buildings [9].

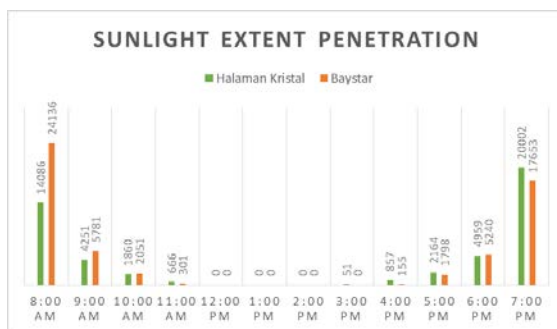


Figure 12 Line chart graph shows the sunlight penetration extent of neo-minimalist and Colonial style buildings [18].

6. Conclusion

The study finds and concludes that the early modern architectural style that applied for the case studies apartment has an excellent shading performance. The study findings show that the last hour of the simulation records the maximum distance of extent of sunlight penetration followed by the first hour and that is due to the low angle of the sun position. However, the results find that early modern architectural style was able to provide an excellent shading performance during the most of the day hours, and especially the afternoon hours which are the most important hours because of the intensive perpendicular sun-ray that is the cause of the main reasons of the heat gain and increasing the indoor temperature. The façade design and the open corridor system are very efficient in term of shading performance; the shading elements manage

to prevent the unnecessary sun radiations from penetrating into the apartments without any sunlight extent penetration during hours of the daytime in Kuala Lumpur. The sunlight penetration during morning hours does not consider bad because of the low intensity of the sunlight and it is considered good for our bodies. The research is strongly recommending to study and reuse the early modern shading elements in the new building design in order to reduce heat gain and as a result to reduce using the mechanical conditioning and energy saving.

7. Acknowledgement

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STAGING THE COLLABORATIVE DESIGN PROCESS: THE POTENTIAL CATALYST FOR BIM-BASED DESIGN STUDIO

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Abstract

Designing is a major activity that supports the introduction, development and implementation of products, services, practices, and systems. Contemporarily, the collaborative approach to designing is considered more efficient than the conventional silo design practice. However, the collaborative design approach tends to be under-researched. Therefore, this research investigates on identifying key components of collaboration as they unfold in the architectural design studio through, student-tutor design interaction in the conventional studio environment. Fifteen (15) weeks of student-tutor design interaction was followed, during which seven students present their designs to the tutor for consultation on a weekly basis. The verbal communication that unfolds between the students and tutor was the data used for the study. After careful study of the data, the study identified the key components of collaboration within the design studio environment, which includes problem framing (issues, scene, difference, and clashes), information searching, idea generation, communication and knowledge transfer. The study recommends possible supports for the identified components in staging the collaborative design studio as expound by the Building Information Modeling (BIM) concepts. To this end, this study has proposed a staging for the collaborative design process which will serve as a potential catalyst for the BIM-based design studio. Future studies can explore on the identified components for possible empirical and methodological research.

Keywords: Design, Collaboration, Studio, Building Information Modelling.

1. Introduction

Collaboration is considered a vital instrument for the successful implementation of complex activities. It potentially serves as an effective ecosystem for knowledge and information sharing, thus facilitating better coordination and increased understanding among the major stakeholders in the main industries like building and construction. The collaborative process can be view as an effective instrument for dealing with complex problems encountered particularly in building design and construction activities. In reality, issues pertaining collaboration are not easy to contend due to the many challenges at hand. Among them is the participation of multiple layers of stakeholders who would bring in a plethora of perspectives, problem parameters and constraints to project implementation. Furthermore, these stakeholders imbue highly differentiated (time) types and levels

of intervention to projects as well the vast array skills, strategies, tactics and methods that come with it. Thus, collaboration most likely necessitates certain changes and adaptation to organizational and project operations about values, requirements, and needs. It could encourage increased innovation to the ways stakeholders practice and perform towards success. Some may advocate complete changes to systems to accommodate effective collaborative processes. Despite these assertions, we are yet to comprehend fully the inner workings of good collaborative activities. What would be good parameters of Collaboration? For quite some time, the construction industry has vigorously promoted collaboration as the way forward to remedy the notorious profligacy of the sector. The promotion of BIM framework and application as a vital platform for collaboration highlights the importance of acquiring congruent and interoperable

information and knowledge transactions between frontline stakeholders. However, this study tries to explore another important view of collaboration ‘interaction’ among design stakeholders. The interaction represents the communication of design information in a collaborative design environment focus on design education. The aim of the study is to explore and enhance collaborative design practice as the potential catalyst for BIM-based design education.

2. Literature Review

Currently, the design process is an independent problem-solving practice, unidisciplinary, knowledge, expertise, problem-solving, training and behavior [1-15]. Even though the detailed design is a joint work but, each stakeholder presents interdependent solutions [16-20]. In a move to encourage the improvement of team design practice Valkenburg and Dorst [21] compared two teams of four students each using protocol analysis. The study established that design characteristics such as naming, framing, moving and reflection have a different pattern of behavior in team design. Chiu [22] established that collaboration is more productive and structured in design practice than design education. In a similar study on collaboration in design Dong [23] found that stakeholders’ language similarities provide productive mental idea sharing among team members. Communication in design can be simplified using some intelligent support systems according to Erkert et al. [24] while, Sonnenwald [25] suggest communication as one of the informant factors for multidisciplinary collaboration. Goldschmidt [26] established that there are almost no differences between individual and collaborative designing. However, other studies [27-36] employed the used of design techniques, tools, strategies and cognitive activities to reveal an effective difference of collaborative design. However, this research intends to look at another dimension of the role of

collaboration in design practice [37-40]. Literature has indicated that technologies of distributed and organizational teamwork will continue to dominate design and construction disciplines [41-43]. Their ability to integrate stakeholders from different disciplines and geographical location working synchronously together are some of the factors that are influencing the dominance. Contemporary design and construction practice will immensely depend on this concept in future. Therefore, these necessitate to a call for a collaborative design platform that can facilitate this process. However, the issue of properly upgrading the conventional design practices is a significant research gap. Hence, this study proposed to investigate the role and effect of collaboration in collaborative design and finally, to develop a model that will contribute to enhancing the concept.

2.1 Collaborative Design

The collaboration is defined as the working together of individuals, group/s or organization/s to achieve define common goal. Individual collaboration is an interaction between individuals, while group collaborations is an interaction between more group and finally, the organizational collaboration is the highest level of interaction which is to companies, institutions, states, countries, and disciplines [44-48],[26]. Collaboration could either be synchronously or asynchronously [49]. Synchronous collaboration the interaction is a real-time and same time such as face to face brainstorming, chatting, video conferencing, apprenticeship, discussion, dialogue, sharing presentation and information. Asynchronous collaboration is a time-shifted interaction; that is different time and location e.g. email messages, audio, and video streaming. Collaboration among other aspects facilitates effective decision making, feedback, ideation, knowledge sharing, discovery, and development. The collaboration was an efficient tool for design and construction

teamwork. Through which layers of information are share, create, integrate, adopt and implement. In a similar vein, contemporary research studies are agitating for a collaborative design ecosystem for product design, construction, operation, and maintenance. This request explores collaboration to be a prominent research component for design, construction and information communication technology (ICT) domains [50-53]. The collaborative ecosystem may require effective planning and managerial provision for it effective setup, implementation, and operation. Some of the issues that may require proper planning are managing stakeholders activities such as knowledge sharing, ideation, clashes and information communication that arose due to clustering of stakeholder working in the same ecosystem and target a single design goal. Furthermore, issues related to collaborative design ecosystem is an area that is equally in need of further studies and clarification. As a result, this study carries out a research observation to identify the role of collaborative design, similarly to determine the effect of collaboration factors in the collaborative design and finally, to develop a collaborative design model for the enhancement of collaborative design⁵⁴⁻⁵⁸. Based on literature studies issues pertaining cost, speed, accuracy, clash detection, and operability are among major solution provided by collaborative design (Table 1). It remains the same the ecosystem for the integration of the collaborative design is not readily available but, it is among the major areas of this study. Some of the objectives of the study include to identify the role of collaboration in design, to determine the factors of collaborative design and finally to develop a collaborative design model. In conventional design and construction practice little is known about the collaborative design and it working ecosystem where stakeholders work multidisciplinary toward a target outcome. The collaborative design model can provide some initial steps for proper

communication, knowledge sharing, iterations and problem-solving for effective project delivery. This research intends to study collaborative design in design education focusing on issues related stakeholders interaction. Some literature has indicated useful advantages of collaboration that relates to speed, error reduction and accuracy in organizational and distributed workings. However, issues related to difficulties that might transcribe from matters relating to managing stakeholders interaction in collaborative design are among issued addressed in this study.

Table 1. Characteristics of Collaborative design: a review perspective

Collaborative Design	Characteristics	Literature Studies
	Observation Interview Brainstorming	Gross ⁵⁹ ; Goel ¹¹ ; Lawson ^{60,1,4} ; Dorst ¹⁰ ; Goldsmidt ²⁶ ; Dubberly and Evenson ⁶¹ ; Danfulani and Anwar ⁶² .
	Text Verbal Metaphor	Goel ^{12,11} ; Danfulani and Anwar ⁶³ ; Stones and Cassidy ⁶⁴ ; Uluoglu ⁶⁵ .
	Prototyping Framing Layering	Danfulani and Anwar ⁶² ; Salmana ⁶⁶ ; Goel ¹² ; Lawson ^{60,1,4} ; Dorst ¹⁰ .
	Modelling Simulation Operations	Macdonald ⁶⁷ ; Gabriel and Maher ³² ; Chung et al. ⁶⁸ ; Dave and Koskela ⁶⁹ ; Faraj et al. ⁷⁰ ; Girlo and Jardim-Goncalves ⁵⁰ ; Gross et al. ⁷¹ ; Gu et al. ³¹ ; Han et al. ⁷² ; Wang and Dunston ⁷³ ; Chiu and Lan ⁷⁴ ; Lee et al. ⁷⁵ .

3. Research Methods

Literature has indicated design problem-solving as a process of phases of events and activities moving from one step to the other with the development, structuring, refinement and detailing of target artefact [13,1,6,11,9,10]. Among methods of studying design, activities are protocol studies. Protocol studies are the most prominent method of studying design process using protocol analysis observation, and interview [80,81]. Eastman [82] conducted the first protocol study in 1968 in which experienced architectural designers were asked to redesign the interior of a residential bathroom [83]. The study involved stages from experimental design,

subject recruitment, conducting experiments, transcribing protocols, coding schemes, quantitative and qualitative comparisons and the final result outcome. Protocol studies could be content oriented and process oriented. The content-oriented approach is the study of the drawings produced, such as sketch, CAD drawings, and models. The process-oriented approach is the study of the process of production such as behaviors, verbal use, and gestures. These is evident from studies carried out by Goel [11] to examine if there are important differences between the cognitive processes involved in design problem-solving tasks, such as architectural, engineering, and non-design such as playing chess or making a medical diagnosis. A total of 16 protocols, twelve (12) from design situations (architecture and engineering) and four (4) from non-design situations (chess playing and medical diagnosis). More recently protocol studies were also used to compare two design working environments, manual pencil and paper and the monitor, keyboard, mouse working conditions, using FBS, Chi-square Test, and Paired –T test. Protocol study was chosen as the research methodology for this study because of its ability to study design activities using behavior, verbalization, and gestures. The methods used for this research is observation. The study involves a design studio space where designers work collaboratively with a design tutor. The research subjects are seven (7) final year undergraduate architectural design students and a tutor working on a design course in a studio environment, the researcher is the only observer in the studio all from Architecture Department, Universiti Teknologi Malaysia. The students are working on their final thesis project; they are required to identify a research problem and find architectural solutions to the identified problem. The studio mentor who is an experienced academician and tutor is working collaborative to guide the students throughout the fifteen (15) weeks stipulated time for the thesis period. During this

period, students met with their supervisor weekly as well as attending panel presentation at certain intervals. Students work are assessed and graded during this presentations using a grading scale provided by the faculty. The data collection process includes all weekly, and specific panel presentations. During which the research data was established. Finally, the study employed qualitative research method using video observation investigate and offer possible properties of knowledge sharing as a variable of collaborative design.

4. Analysis & Results

The study employs qualitative research method of analyzes data from direct fieldwork observations of design studio activities, using designers behavior, verbal, visual and textual design information communication as the medium of the analysis. In some circumstances interviews, and analyzing written documents were also carried out. Qualitative research analysis further engages in analyzing the setting of the studio environment to generate rich narrative descriptions and construct a proper understanding of the concept. Inductive analysis across many cases in the design process yields patterns and themes of collaboration in the design session which is the fruit of the qualitative research study. The research data obtained from retrospective observation of the studio activities, necessary subject interview, were also carried out. The observed data revealed some unique features of knowledge sharing in the design process. The identified features occurred during the conceptual process of analyzing and generation, product information communication and detailing, and finally, new tacit knowledge development through testing, modeling, and operation. The analysis has also established collaboration as a modality of knowledge sharing. Therefore, it understanding will contribute to efficient design information sharing among stakeholders in the design process. It was

also understood that, in design sharing, and peering of knowledge and information among stakeholders are all facilitated through collaboration. The analysis also indicates that one of the significant aspects of collaboration in design is knowledge sharing. Therefore, effective collaborative skill will assist in molding designer with effective knowledge sharing skills.

This study has found collaboration as the mechanization of the design process which translates into a knowledge sharing system. Also, this study has also found that design process involves integration and transformation process of information searching, information identification, information structuring and finally information implementation. This study further established that the interaction between tacit and tacit knowledge in design determines designers' level of experience and the availability of information on the client, user, site, environmental, climatic and atmospheric information. These imply that designer collaboration with team members, users, and the environment is of paramount importance. These support the notion that design is also a knowledge sharing process. According to [61] design process could also be a knowledge sharing the process. Thus, this study could add up to the notion that collaboration facilitates knowledge sharing in a controlled studio environment. Collaboration could term as the modality that links design and knowledge sharing, through an interview, brainstorming, verbalization, sketching, framing, layering, modeling, and operation. The knowledge sharing process includes the interaction between tacit and explicit (Figure 1). It can conclude that there exist a link between design and knowledge sharing. It became even clear through examining the effect of collaboration on the two processes. This study has been able to connect knowledge sharing and design process. The study has been able to address theoretically the hypothesis that design is a knowledge creation process. The study

further used collaboration as a modality to explore the link further through observation of collaborative design between student designers' and a tutor. Other findings also suggest that design facilitates knowledge transformation from the tacit to explicit domains of knowledge, however, future studies can still justify the suggestion. Based on the understanding of collaborative design so far, this study developed a four-stage model of collaborative design. The model also includes the method of sharing explicit and tacit knowledge in the design process. Also, the model provides some understanding of how to plan the operation of the collaborative design. The four stages of the model represent the collaborative design process. Further studies can develop, refine and expand the model where necessary. The concept of provided by the building information modeling BIM-based collaboration is a multidisciplinary collaboration concept that enhanced and simplified teamwork. Future studies can provide adequate research whether the BIM-based collaboration can provide disambiguating simplification of design as a knowledge sharing the process. It concludes that collaboration is a catalyst for design as knowledge sharing. Therefore, any improvement in design collaboration can result in the achievement of a better outcome and knowledge creation and gain.

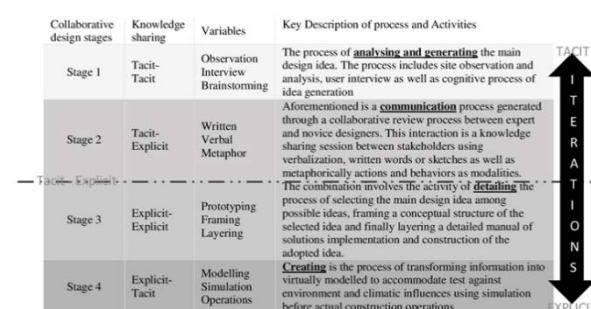


Figure 1. The four stages Collaborative design Model

4.1 Stage 1

The example of stage one includes a brainstorming session that facilitates the understanding of the design requirement, investigation of different design context and

cognitive process of innovation. By observing design requirement such as sociocultural influence, economic and environmental influences through designer – user interaction, visual and retrospective observation of user activities as well as generating mental ideas through brainstorming (Figure 1) of possible design solutions.

4.2 Stage 2

Stage 2 are factors that influence the progressive transformation of initial design concepts. Designers communicate, validate, transform and assess their design through a certain medium of Textual, Verbal, and Metaphorical methods are some of the common methods of design externalization. Through which expert and visionary designers challenge competent, and novice designers design with criticism such as disapproval, faultiness, correctness or mistakes. Through this criticism expert and visionary designers' analysis competent and novice designers' design and make judgments', improvements and meaningful contribution to the design. Stage 2 clarify ambiguous design discoveries are clarified in design presentations and meeting through written or prescribe feedback, verbal or oral feedback as well as metaphorical actions and descriptive behavioral feedback.

4.3 Stage 3

Initial design ideas are abstract spatial depictive. However, Stage 3 is transformational process successfully transform and communicate design idea from abstract to concrete spatially specific artifacts. The Stage 3 process includes prototyping, framing, and layering of the artifact. Prototyping is the process of using exemplary existing product or artifacts to compare merit and demerit with the proposed design. Framing is the process of outlining proposal, zoning, diagraming and planning of the proposed design. The framing represents the actual preliminary structure of the design. Finally, layering represents the arrangements, distribution

and documentation of different phases of the design in the form of plans, sections, elevations, site plans and perspective views.

4.4 Stage 4

Stage 4 is the process of developing, testing or implementing designed product or artifact. In this stage, the schematized design transforms in a concrete form either to carry out a test or actual design adoption. Stage 4 includes the information driven from virtual building models. Model of product or artifact give some sense of views, construction processes, clash detection and cost analysis. Designs undergo simulation as to analyze and test either atmospheric conditions, energy efficiency, solar radiation, day lighting or other design requirements.

5. Discussion & Conclusion

Literature has not provided substantial evidence the operation of the collaborative design. However, in this study knowledge, sharing has been identified as a modality that can describe the operation of the collaborative design. Being an interactive process, through knowledge sharing activities such as observation, interview, and brainstorming between individuals and groups collaborative design is carried out. According to [79] knowledge sharing can be facilitated through verbalization, written script, behavior, and actions. During studio presentation, stakeholders make uses these modalities of collaboration in design. Sometimes it may extend to the use of documented referencing or exploration of ideas using sketches and metaphorical description in the form of action, signs, behavior, and gestures. Student designers collaborate with experienced tutors to share, identify, develop and create knowledge embedded in the design process and product developed. They also used the opportunity provide by the collaboration to develop their tacit knowledge that accumulation will transform to another level of expertise. The explication of tacit knowledge is an advanced level of

knowledge development that assist in producing an effective understanding of mental ideas, misunderstanding, and clarification of the ambiguous situation. This study uses protocol studies¹¹ to understand the characteristics of collaborative designs^{79,61} in the design process. The analysis indicates that collaboration between designers has externalized the relationship between knowledge sharing and design. In the socialization context of the knowledge sharing, students collaborate with a tutor during design conceptualization through observation, interview, and brainstorming. The collaboration is normally a studio interaction where issues about constraints, requirement and bylaws are discussed and scrutinized. During this period, designers' knowledge coordinated and shared. This coordinating process will end in revealing the actual discovery of the new design concept.

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BIM KNOWLEDGE: AN AVENUE FOR CONSTRUCTION INDUSTRY DEVELOPMENT IN MALAYSIA

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Abstract

The global development trend in construction industry is the adoption of Building Information Modeling (BIM) for project delivery process. Malaysia is identified as a fast growing nation with potentials to be in the league of developed nationals; to achieve this, BIM is inevitable. The adoption of BIM for project delivery is majorly a function of awareness, technical skills, collaboration and education among all professionals specialization in the industry. However, the moves to embrace and adopt this technology by the industry have been slow and this is largely due to low or complete lack of knowledge. This study therefore provokes the opinions of the practitioners in the industry by interview and data therefrom was analyzed using qualitative analysis software. Thirteen respondents include; architects, quantity surveyors, engineers, contractors and project/facility managers in practices were interviewed. This study therefore, identified the importance knowledge to the development of construction industry in Malaysia..

Keywords: Building Information Modeling (BIM), Knowledge, Awareness, Avenue, Development And Delivery Process

1. Introduction

Construction industry have been found to play crucial roles in the provision of necessary infrastructure such as housing, roads, hospitals, schools, and other basic facilities, for good quality and to improve the socio-economic growth of most developed nationals around the globe [1]. Though, construction industry is of importance to any economic worldwide, but it still remains one of the most challenging industries in this present age, with low reliable rate of profitability, little investment in research, education and development. Also, the problem of training of beginners for replacement of aging workforce and the present market needs of experts with adequate modern technological training are among the major problems that needed urgent attention [2].

The adoption of Building Information Modelling (BIM) technology has come as a relieve to ease the pressure on the industry in order to provide value for money, creating opportunities sustainable design and construction, and to find solution to other problems bedevilling the industry. However, BIM is transforming the paradigm of the industry from 2D lines based drawing systems to nD object based information systems [3]. Yusuf, Ali [4] also maintained, that BIM is a modern delivery tool that is widely in use in the construction industry which is becoming international benchmark for efficiency in Architectural, Engineering, and Construction (AEC) and its influences and benefits are still unfolding.

Macdonald [5], noted that despite the enormous BIM benefits, its benefits cannot be fully achieved due to limited knowledgeable workforce in the sector. This made her to maintain that education

remains the only option for balancing the inadequacy in the industrial market needs of competent workforce. In Malaysia's construction industry, adoption of BIM by industry players is having challenges of implementation because of lack of knowledge and execution guideline for them to follow. In order to overcome these impediments effort are geared towards development of training and education program that will enables changing management style and developing new roles and responsibility [6].

2. BIM Knowledge

From series of study it is apparent that BIM pursues the aptitudes to change and revamp the performance of AEC industry, with the hope that inefficiencies will reduce, productivity enhanced and collaboration, communication and free flow of information will be upsurge [7]. Furthermore, with BIM there is the potential to achieve decreased project costs, increased productivity and quality, and reduced project delivery time [8]. In spite of the success factor perceived of the BIM and the envisage potential, the embracement, Becerik-Gerber, Gerber [9] noted that the adoption of these opportunities has remain low. Knowledge as human resources in any capital development has be found to be an important factor that determines awareness of the society. The overall level of education of the society is essential for productive use of new technology [10, 11]. Castells [11] advised that the only avenue for this to be achieved is by starting with the creation of knowledge and awareness among the society in question. Besides, the ability to adopt and practice BIM technology depends on knowledge of the complex process information manipulation

and assimilation. Furthermore, Bernstein, P.G. (2010), suggested that BIM knowledge should be made available to professionals in the construction industry, but also warning that failure to this will create a fundament setback in the industry. Enegbuma and Ali [12], noted that the Malaysia government through its agencies such as Jabatan Kerja Raya (JKR) and the Construction Industry Development Board (CIDB) were aware of the importance of BIM as an emerging technology that is revolutionizing the entire construction industry.

3. Theoretical Basis For BIM Knowledge

Theoretical basis is the structure that can hold or support a theory of a research study The Project-based Learning (PBL) model is important in the learning process. It is touted to be the approach and means to achieve the 21st century skills. Moving away from traditional learning style, Project-based Learning (PBL) builds on individual strengths, and allows individuals to explore their interests, it also incorporates the principles of providing challenging and complex work, interdisciplinary and encourages cooperative learning. Project-based Learning also lends authenticity to learning. While in practice, practitioners plan, implement and evaluate projects in real-world situations beyond the classrooms. Project-based-learning experiences are often designed to address real-world problems and issues, which is complex, interconnecting, and ambiguous, sometime project-based learning may be called *inquiry-based learning* or *learning by doing*, since the learning process is integral to the knowledge and skills students acquire. [13]

Computing and networking technologies offers new opportunities to support inquiry-based learning. This was identified by Blumenfeld, Soloway [14] , who spelt out the six contributions that technology can make to the learning process, that is

- i. Enhancing interest and motivation.
- ii. Providing access to information.
- iii. Allowing active, manipulable representations.
- iv. Structuring the process with tactical and strategic support.
- v. Diagnosing and correcting errors.
- vi. Managing complexity and aiding production.

In the knowledge transfer of BIM in any academic setting, interest and motivation are of great importance, this is to provide access to information which will enable students to be active through a process of tactical and strategic support. The aspect of conflict detection and resolution is made handy to manage complex models from all project team members to deliver the project to the best practise. Edelson, Gordin [15] explained that computer technology offers benefits for inquiry-based learning for large data storage and manipulate of information both in visual and audio formats; it also supports complex computations for communication and expression with the ability to respond rapidly among project team members. These qualities of PBL in the knowledge transfer and integration of BIM to education made it a promising technologies developed for learner and adopted for BIM to enhance ability of virtual appreciation of digital project before real life reproduction [14, 15]

4. Research Methods

The appropriateness of the data collection method adopted was due to the explorative nature of the study, BIM as a new paradigm that is still finding it feat in the construction industry, requires more and adequate information that will gives an unbiased conclusions. The target populations for the study are the stakeholder in the construction industry in Malaysia; with particular reference to those that have already adopted BIM for their practice and those with BIM technical knowledge. Deciding on the number of sample size that will adequately represent the population comes in when the point of saturation is reached; when an additional respondent give no additional new information to the data set already secured. This allowed the researcher to determine and decide on the sample size. Thirteen respondents were interviewed to reach information saturation level; these comprises of architects, engineers, quantity surveyors, project managers and contractors that have adopted BIM and are active in the BIM awareness campaign. To source audience for these categories of respondents a modified snow ball technic was adopted in order to locate those stakeholders that have already adopted BIM, as they are few in number. For the analysis of the study, MAXQDA 12, which is a CAQDAS software was adopted. The choice this analytical approach was based on its suitability for easy coding, data display, data mapping, importation and exportation of data and interrelation of various data for analysis purpose [16].

5. Discussion and Findings

In order to appreciate the need for BIM knowledge and way of realising it, the impediments that are standing on the way of

adequate BIM knowledge must also be identified and highlighted for better appreciation of reasons for research solution outcomes. This section discusses the challenges facing acquisition of BIM knowledge and the needs for the establishment of adequate BIM knowledge in order to pave an avenue for the

construction industry in Malaysia to realise its potentials at full adoption of BIM. From the code matrix browser of the interviews as illustrated in figure 1, which shows the distribution of respondents' comments as regards BIM education challenges and the needs.

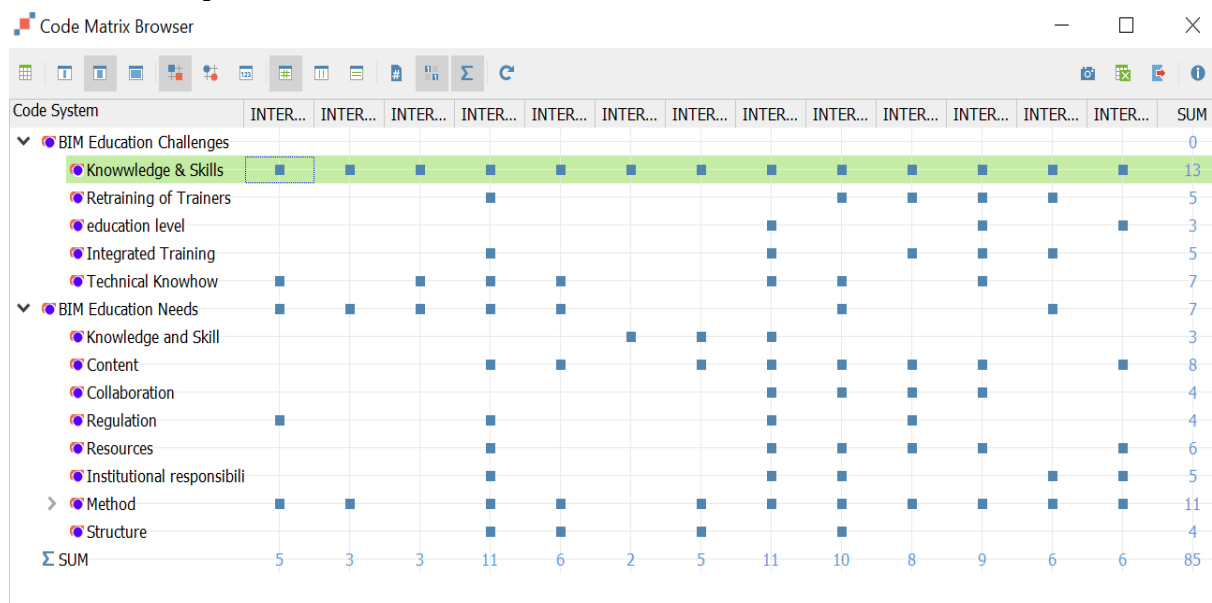


Figure 1: Distribution of Interview Respondents

From the distribution of interviewees' comments as presented in figure 2, 100% of respondents agreed that BIM adoption in the industry is majorly impeded by lack of knowledge and skills. Next to it is the lack of technical knowhow in teams of software(s) and hardware(s) technology. While the least problem of adoption is the education level with 23.1%, this means that the industry needs more of technical knowledge to forge ahead.

5.1 BIM Challenges

These are challenges that are facing BIM adoption as a result of non-adequacy of

knowledge and training in construction industry in Malaysia. Deducing from the interview, many of the respondents expressed that poor BIM adoption was as a result of non-establishment of education system to cater for the industrial workforce needs. Some of these challenges include the absence of knowledge and skills; absence of retraining of trainers, in adequate level of education; non-integrated training and poor software technical knowhow. Inferring from the comments made by the respondents indicated that BIM knowledge and skills constitutes a major setback for BIM adoption.

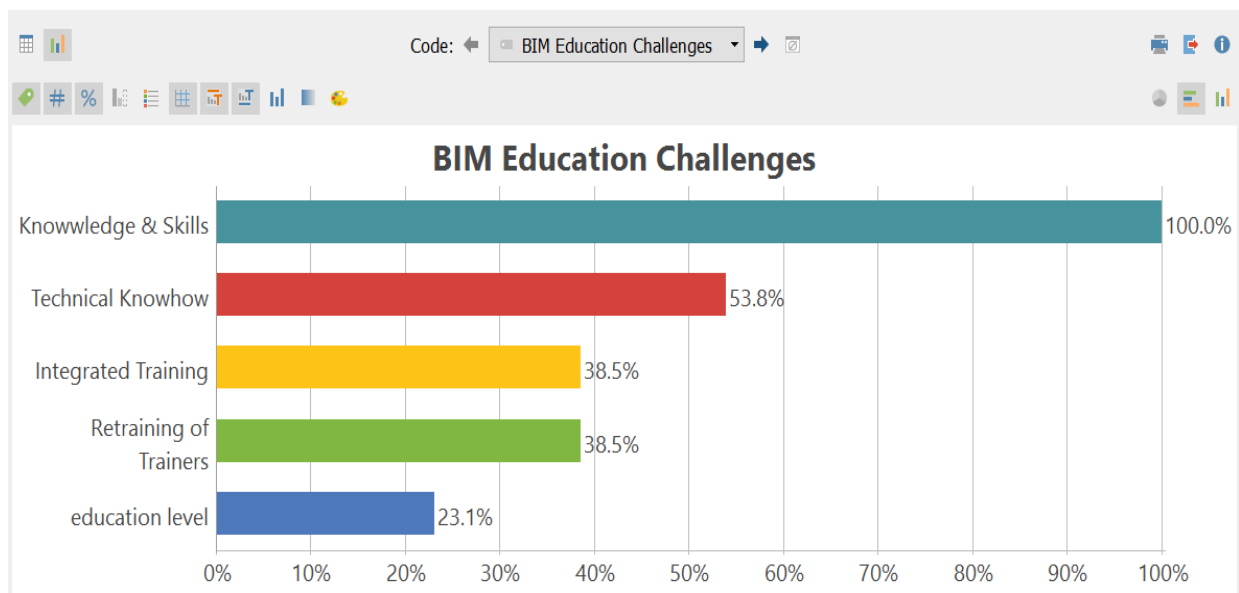


Figure 2: BIM challenges in the construction industry

5.1.1 Knowledge and Skills

All the respondents acknowledge the importance knowledge and skill to the adoption of BIM and the lack of it have been the main impediment to wide spread of BIM adoption. Many of the interviewees argued that because of lack of BIM knowledge many consultants firm only procure both the software and the hardware for BIM and keep without using them for their projects, as taken from the interviewee accounts as:

“The level of BIM in Malaysia have not reach that level, because it knowledge spread is still very limited among practitioners...limitation of knowledge and awareness among professionals and there is low level of BIM developer / industry”

The study also found out that many stakeholders are willing to adopt BIM in their respective specializations, but lack knowledge stands on their ways and they decide to stay with the traditional methods of project delivery even when they can afford the cost of setting up a BIM office. For instance one of the respondent opt that:

“I believe that there are large opportunities for design innovation and creativity but in Malaysia not all the consultancy firms are willing to use BIM because of lack knowledge and awareness...Lack of complete information by the design team as to the proper usage of BIM and this is largely due to limited BIM knowledge”

5.1.2 Retraining of Trainer

The retraining of trainer is a process where educators go for further training so as to keep abreast with the latest technology. Most of the educators are still to be acquainted with the latest technology; this is a challenge. Taking cognizance of comments from the respondents retraining of educator is paramount to BIM adoption, examples of such comments are:

“Okay, about education, I think, first of all, the lecturers have to get trained first, they have to go through school, perhaps retraining, probably be it at the industry, be it at CIDB, be it IDB, then they get at the understanding”

5.1.3 Non-integrated training

Formal education occurs in a structured environment whose explicit purpose is teaching students, an educator must therefore possess the required explicit knowledge to qualify to education students. Thus, the BIM education qualification needed for the production of competent workforce is still in lacking as can be deduce from comments from respondents. Another area of impotence is the integrated training among relevant departments and faculties. This tradition encourages collaborative education among various construction industry specialties starting from higher education.

“Now how can we make our BIM knowledge to grow from secondary school level for BIM appreciation in form of BIM definition, then in technical education, diploma and high diploma level to be exposed to the technical aspect of BIM. And for the higher institution (B.Sc., M.Sc., and PhD) this are exposed to the basic principles and the management technicalities of BIM”

5.1.4 Poor Software Technical Knowhow

Technical knowhow is also identified by the respondents as lacking in the training of students at higher education institutions. In addition, apart from the inadequate manpower without adequate technical knowhow needed, the software and machines need to be made available. As pointed out by one of the interviewee that:

“I have BIM, I have Revit in my office but I’m not using it due to lack of BIM operators. So this problem will be solved for there will be more BIM graduate to be absorbed by the market.”

5.2 BIM Knowledge Needs

Education have been found to be the spine of BIM adoption, in this case a number of needs have been identified by interviewees, these are to reposition the BIM education of the industry in order to adequately combat some of these challenges. Deducing from the interviews, as presented in figure 3, some of the needs are: improve knowledge and skills; education contents; collaboration; regulation; resource in teams of capital and machines; institutional responsibility; method and structure of BIM education deliverables.

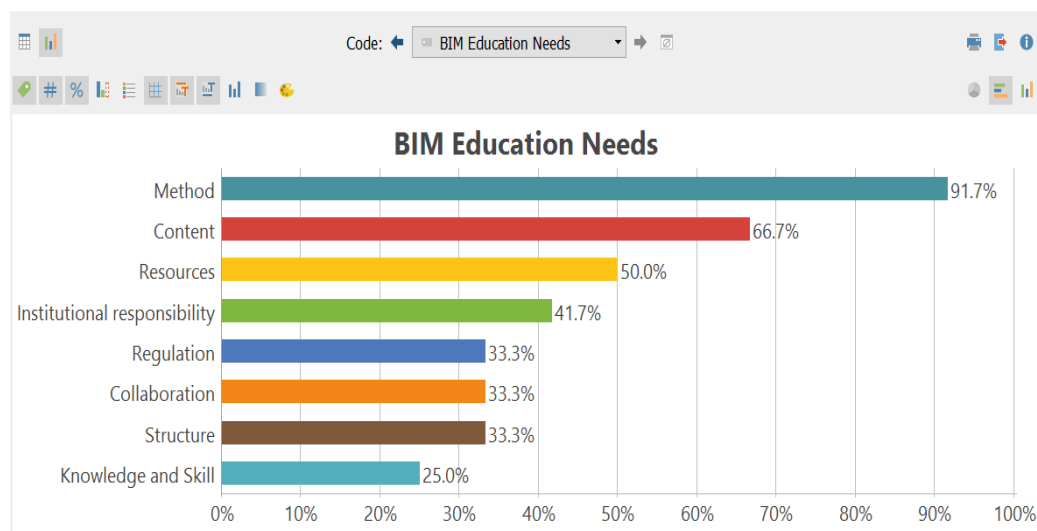


Figure 2: BIM education needs for construction industry

5.2.1 Improve Knowledge and Skills

Adoption of BIM can only be consolidated with good BIM education which is built upon the knowledge and skill of the technology. About 75% of the respondents acknowledged that BIM education across all educational stages (secondary, technical and university education levels) are important to the construction industry and therefore must be included in BIM educational plans of the construction industry in Malaysia.

“What knowledge do we need to give all these category of people, because secondary school knowledge is very important, technical education is very important, and university education is also very important, and they work hand-in-hand”

5.2.2 Collaboration among the Industry and Academia

Collaboration is the working together of the industrial practitioners and the academic for the overall development of the construction industry, and it is of importance to the production of BIM competent workforce. Collaboration is one of the breakthroughs of building information modeling because it affords the industry an obstructed free flow of information sharing. However, respondents recognized that BIM adoption needs collaboration among the industrial player especially the industrial practitioners and the academies. They also argued that the roles play by each party is complimentary and none can be dispense with.

“That is why I think the discussion between academia and the practitioners should be intertwined, and the other thing that they should be done is perhaps, the university

could use these mean, that is, they have this understanding of this concept of, okay, only if you are qualified, you can go and teach”

5.2.3 Resource (Software and Hardware)

The resource needed for setting up BIM education in higher education is enormous. This fact is agreed upon by all the respondents, but some are of the opinions that resources are not of problem to the institutions, because they are being supported by the government with grants that is needed for both software and hardware for BIM setup.

“In Malaysia the universities have more grant than the private practices, the university should be able to buy the needed software and hardware and to be able to conduct training for their students”

5.2.4 BIM Education Deliverables

For the education institution to be up to task of producing BIM workforce for the construction industry, the study identify that there is need for curriculum that addresses the basic principles of BIM. Though, the respondents identify two type of BIM education that is: business BIM education and the academic BIM education, but more emphases is place on the later. Among the deliverables needed by the academic institution from the opinions of the interviewees is that various BIM software(s) should be taught in addition to the main specializations.

“there must be a (BIM) curriculum to your being encouraged, alright, to seek the proper understanding of the principles of BIM; the basic thing about what you are doing, the little thing, and then you go away with the correct curriculum”

5.2.5 Institutional Responsibility

Academic institutions are the custodians of knowledge and skills, it is on this note that many of the respondents believed that academic institution roles and responsibilities are important in the development of BIM education in the construction industry. From the interviews it is identified that higher education should be specialized in the educating and training of upcoming professionals, also the interviewees are of the notion that institution should focus on the supply of needed workforce for the industry.

“So this is where we need to explore to make sure our institutions of higher learning are specialized in certain area of the industry.....But for the time being, we need to look for the education, then focus on the education demand and supply, and the usage of these tools that you want to implement to operate, manage the human resources”

6. Result and Conclusion

In order to keep with the BIM global developmental reality, BIM knowledge is key and the utmost need of the construction industry in Malaysia. The moves to embrace and adopt this technology by the industry practitioners have been slow and this is largely due to lack of knowledge and awareness, due to some impediments as highlighted in section 4.1. The industry BIM knowledge needs as discussed in last section indicated that, adoption of BIM with adequate knowledge is the only sure way to guarantee the development of the industry in Malaysia. In summary, the author believes that BIM integration to education institution will be the antidotes for lack of BIM

knowledge and the only way to develop the industry to an international standards.

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PROPOSING ROBOTIC FOLDABLE HOUSES FOR A HALF-DAY URBAN LIFESTYLE

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Abstract

With the increasing cost living in the downtown, the issues from misdistribution of the accommodation and the work places for office workers become worse and worse. Linking together them can not only ease urban traffic congestion but also save much time for the office workers. By utilizing the vacant time of some public areas, this study proposes the robotic foldable houses for a half-day urban lifestyle. Based on the grounded theory, this study has outlined benefits from application of robotic foldable houses. Meantime, this study also sets the design requirements for the sample units by analyzing the characters. Finally, this study concludes with the good performance of the proposed units in sustainability, efficiency and effectiveness.

Keywords: *Robotic Folded House, Half-Day Lifestyle, Sustainability, Urban Design*

1. Introduction

Buildings have long been associated with unmovable stereotypes. However, with the acceleration of city developing and population harvesting, the cost of living in downtown has been incessantly rising and the land use in the city central has been pushed to the edge of sacristy [1]. In addition, the narrow space and overpopulation in the downtown have resulted in the increasing travelling time and distance from one zone to another. Therefore, meeting the needs of metropolitans is perhaps the urgent application of a foldable building that can be quickly linked together the accommodation and the ephemeral communities. As a matter of fact, the central areas that are subjected to publicity such as squares, pedestrian zones, plazas, and so on, are normally fully utilized during the daytime but vacant at night. This fact highlights the possibility of operating such spaces as living environments during nighttime. This study proposes a new adaptable living lifestyle, the half-day urban lifestyle, for metropolitans to

accommodate arability. The theory is based on designing robotic foldable residential units to achieve spatial utilization as well as to contribute efficient lifestyle. The proposed units can be folded at daytime enabling normal business activities and erected automatically during nighttime when the business closed [2].

From the geospatial development point of view, the robotic foldable house is undoubtedly favoring the urban developing concept of mobility, foldability and flexibility. It is highlighted most that this type of building can not only be manufactured and placed in position quickly but can also perform its ability to fold and unfold automatically during its needs without making it cost too much. Moreover, by utilizing its advanced features, this type of building is so versatile that also can be used a mobile working station to cope with urgent circumstances such as urgent aids, earthquake rescuing and so on [3].

As the application of robotic foldable houses becomes popular to the public area design, the transformation from publicity into privacy and from normal business function to residential dwelling function is crucial. The building itself will be making no influence to the public activities in the daytime and maintain its accommodability to achieve this novel urban lifestyle in the nighttime. The proposed areas should be capable for accommodating a certain number of houses and making no influence to the existing commercial environment [4].

2. Research Methods

This study follows grounded principles to review relevant technologies in order to validate the proposed concept. Adaptable means of approaching this idea is determined using current knowledge of prefabricated houses and content analysis. The majority determinants from this approach can be revealed as followings.

1. The proposed area should be investigated in order to fulfill the architectural design requirements for the dimension of the houses which should be ensuring user-friendly and cost-effective. The architectural appearance of the whole units shall be well dedicated and integrated with the neighboring physical environment and bio-environment, in which, the foldable units aimed to create not only a novel living lifestyle but an adaptable scenic view within the neighborhood as well.

2. The environment of the neighbors such as the fabric of the buildings, the height, the orientation and other elements will be taken into account when approaching architectural and structural design for the sample units, to ensure architectural harmony within the neighborhood. The fabric design for the proposed units is crucial to achieve indoor thermal comfort that prompts living condition when the house is occupied. The orientation of the house is an important parameter that associates with illumination, taking

advantage of valuable natural sunlight source as much as possible for solar power plant during the daytime. Meantime, carefully chose the area that could possibly be shaded by the erected structures.

3. The environment assessment should be taken into account during the processes of both pre-construction and post-construction. The commercial activities in daytime are much more important in this zone. Therefore, the proposed units will do no interruptions to the business activities. In response to that, the proposed units shall be in a better form that “hide” underground without making deterrent for people to access the main commercial building or plaza. Meantime, the feasibility investigation must be carried out to assess potential advantages and disadvantages. After construction, it is also a necessity to inspect whether there is a potential adverse impact on business activities.

4. The interior design of the sample units is vital to achieved better living environment. The parameters for the inner walls, the ventilation systems, and the interior facilities will be taken into consideration as the appearance of which is of favorable to be compelling to fit the surroundings.

5. Safety issues should be considered for designing the houses. The safety issues are more likely to occur during the nighttime. As the houses are designed for the night use, the safety cannot be emphasized more. Thus, a detailed design for the doors and windows toward a safer and cozy living environment should be involved.

6. Relevant robotic technologies and Building Information Modelling (BIM) techniques should be integrated for the proposition of the sample units. The 3D visualization is of great help to the construction, operation and maintenance of the sample units. BIM technologies are applied to ensure the buildings is well tuned.

3. Analysis & Results

- a. The application of the proposed system is expected to diminish the research

problem through the potential development of various advantages namely; formation of affordable robotic temporary housing, minimization of urban/suburban commutes/traffic congestion, decreasing environmental pollutions, and so on.

b. The proposed foldable units are expected to be hidden underground during daytime and erected only during the night to prevent negative impacts on daily routine urban lifestyles during the daytime.

c. The proposed foldable units are expected to be able to be erected automatically and close down for adjustable time settings to cater hassle-free implementation/automation.

d. The folded houses are expected to be self-sustained.

e. The proposed foldable units are expected to be straightforwardly mass-producible.

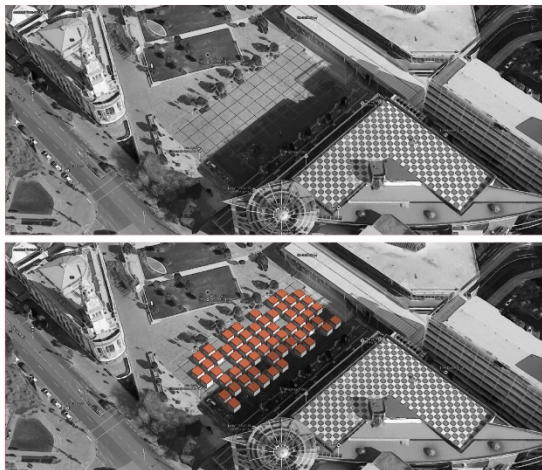


Figure 1 Robotic foldable houses (daytime/ nighttime)

4. Discussion & Conclusion

Various advantages can be perceived as the result of applying the proposed system.

a. The buildings will be made from green materials that can be recycled, biodegraded, or reused in other circumstances.

b. The building is structural efficient and architectural aesthetic.

c. The building is affordable and adaptable, providing indoor thermal comfort and safety. However, widespread application of the proposed units must be thoroughly investigated as an integrated part of urban nightscapes to minimize its potential social challenges.

The application of robotic foldable houses is sustainable because it not only has the potential to achieve the effectiveness of land use in the city center, but also delivers a half-way lifestyle for those who willing to adapt the easy way of accommodation without spending too much time on travelling and feel secured during occupancy. This application aimed at utilizing the land use in the urban area, absorbing the pressure from the metropolitans who stressed on accommodations and providing as much convenient living lifestyle as possible. The erected houses can be versatile in multiple applications in the future, and it can also be repositioned and environmentally friendly. The role of the robotic foldable houses is a prompted means to improve the efficiency, quality and environmental performance of downtown house use.

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QUANTUM CHEMICAL MODELLING PROTOLYTIC EQUILIBRIUM ON SURFACE OXIDE MATERIALS

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Abstract

The results of calculation of the acid and basic properties of a surface of the disperse oxide materials on the basis of SiO_2 , $\alpha\text{-Al}_2\text{O}_3$, $\alpha\text{-Fe}_2\text{O}_3$ and TiO_2 by the method of quantum chemical modelling are presented in the article. The correspond models of the superficial active centres for this purpose are offered, the constants of their protolytic equilibrium pK_a and free Gibbs's energy deprotonation reactions are calculated. It is established, that acidity of all types of the superficial active centres increases among $\text{Al}^{3+} < \text{Fe}^{3+} < \text{Si}^{4+} < \text{Ti}^{4+}$ depending on the nature of the central element. The acidity of the isolated centres grows at increase of quantity of OH-groups. The vicinal superficial centres $\text{Si}_2\text{O}_5(\text{OH})_2$ and $\text{Ti}_2\text{O}_5(\text{OH})_2$ have the greatest acidity from all spectrum of the researched centres. It is established by the results of calculations that the acidity of the active centres grows at increase in quantity of the adsorbed water molecules at surfaces for all disperse oxide materials. This dependence is approximated by the linear equation of a kind $pK_a = \theta \cdot n_{\text{H}_2\text{O}} + pK_a^0$, and the free member pK_a^0 has real physical sense of an indicator of acidity of the waterless active centres.

Keywords: The Acid And Basic Properties, Quantum Chemical Modelling, The Active Centre, The Disperse Oxide Material

1. Introduction

One of the major sections of modern polymeric materials technology is physic chemistry of the superficial phenomena in composite materials. The urgency of this direction is connected with creation of new building polymeric composites, many of which are heterogeneous systems with advanced interfaces of phases. The properties of a surface of the dispersible phase define the initial stage of adhesive interaction - adsorption, wetting, flowing property of polymeric binding on a surface of the filler, formation phases' partition border, imbibitions of the filled and reinforced systems by polymers. The disperse mineral oxide materials which advantages are connected with availability, cheapness, and also possibility to receive building materials with a complex of necessary properties are more often applied by working out of new polymeric composite materials for building like fillers. The chemical and mineralogical structure of these fillers and, accordingly, their

superficial properties are extremely unstable in connection with their natural origin. Besides, disperse particles of the oxide materials, having superfluous superficial energy, easily adsorb molecules of water from air, which form the hydroxyl and hydrated layer in the form of the active centres' wide spectrum and which acid and basis properties are studied insufficiently [1,2].

2. Literature Review

It is known, that the structure of adsorptive superficial layer of the oxide materials consists of chemically connected water molecules forming a layer OH-groups (Brensted's active centres) and the subsequent hydrated layers from the water molecules connected with hydroxyl layer by means of hydrogen communications. Besides, it is supposed, that the aprotic Lewis's acid and basic active centres which quantity on air-dry surfaces, apparently, is insignificant, can be presented on a surface. Definition of the acid and basic

characteristics of the active centres of a superficial layer of the disperse oxide materials is a difficult problem, but it is very important, from the technological point of view. The literature review testifies that the methods, allowing to define quantity and properties of the superficial active centres are basically experimental [1-3], and also are settlement based on quantum chemical models [4], they often lead to inconsistent results.

The most widespread disperse fillers for building polymeric materials are materials on a basis of oxides Si, Al, Fe, Ti and some other elements which maintenance it is possible to consider as extrinsic minerals. Research of the acid and basic properties of oxides' surface by various methods leads to inconsistent conclusions that is connected not only with their unstable chemical and mineralogical structure, but also substantially depend on technology of preparation of samples, dispersion, conditions of storage and many other factors which define the degree of a surface's saturation by water molecules. It is obvious, that presence of the adsorbed water molecules and their quantity essentially influences acid force of functional hydroxyl groups of oxides' surface [1].

The data about laws of change of acidity of the active centres from the degree of oxides' hydration for the various chemical nature will help to interpret existing experimental data, and also to predict the superficial acid and basic properties of the superficial active centres in mixed oxide materials.

The work purpose is application of quantum chemical modelling for an estimation of acid force of the active centres on a surface of the mineral disperse oxide materials.

3. Research Methods

The approach based on the chemical and mineralogical nature of acid force of the superficial active centres of disperse oxide materials is applied in work. This approach takes into attention the modern information about structure of the surface air-dry oxides. The applied approach is based on some representations:

1) Two types of functional hydroxyl groups with various acid force – the isolated and vicinal active centres (a layer of water molecules chemically connected with a surface) is present on the oxide materials' surface;

2) The gaseous water by the means of hydrogen communications (layers of physically connected water molecules), forming a wide spectrum of the active centres is adsorbed on the hydroxyl surface groups in the form of clusters, consisting of 2-4 molecules;

3) The acid and basic parameters of the superficial active centre are defined by a parity of power and dimensional characteristics of all components of geometrically co-ordinated structure of a fragment of the crystal lattice, and also by presence of the adsorbed water molecules.

Authors [2] offer the formula for calculation of acid force of differently charged ions existing in water solutions or on a surface of the firm bodies:

$$pK_a = pK_w - \frac{r_{E^{n+}}(cn)}{r_{OH^-} \cdot N(cn)} (I_3^{n+} + m \cdot A_{O^{-2}} + k \cdot I_H^+), \quad (1)$$

where – pK_w – ion product of water; $r_{E^{n+}}(cn)$ – radius of the central element with coordination number N , nm; $r_{OH^-} = 0,153$ nm – radius of the functional hydroxyl group; I_E^{n+} – the energy of the central element ionisation, eV; $A_{O^{-2}} = -6,76$ eV – the energy of affinity of ion to electron O^{-2} ; $I_H^+ = 13,59$ eV – the energy of proton ionisation; k and m – stoichiometrical coefficients.

Those circumstance, that calculation is conducted only for the hydrated ions existing in the water environment, limits application of the given formula for definition of acid force of the air-dry disperse materials' superficial centres.

4. Analysis & Results

The indicators of acidity of the superficial active centres of oxides with central elements Si^{4+} , Al^{3+} , Fe^{3+} , Ti^{4+} have been calculated using the formula (1).

The models of the superficial active centres of oxide material, in which structure the following atoms directly connected with the active centre are included: the central element with coordination number N, oxygen atoms, OH-group atoms, and also water molecules, have been used for calculation of acid force of the active centres of a surface. These active centres are the isolated ones containing one, two and three OH-group, connected with the central element E^{n+} , and also vicinal ones, containing two elements E^{n+} and two OH-groups, united by hydrogen communication. The bridging groups, which are the centres with exchange protons, are situated in cavities of a surface and were not considered in research. The calculations were made for the hydrated active centres containing from one to five water molecules, which are adsorbed according to the known mechanism of superficial OH-groups hydration [2,4].

The power and dimensional parameters of the superficial active centres used for calculation of their acid force are presented in tab. 1.

Tab. 1. Power and dimensional parameters of the superficial active centres

Central element (E^{n+})	N	$r_{\text{E}^{n+}}$, nm	$I_{\text{E}^{n+}}$, eV
Al^{3+}	6	0,061	28,44
Fe^{3+}	6	0,067	30,65
Si^{4+}	4	0,042	45,13
Ti^{4+}	4	0,056	43,24

Free Gibbs's energy of deprotonation reaction of the active centres at $T = 298\text{K}$ is calculated under the formula $\Delta G = pK_a \cdot 2,303 \cdot R \cdot T$ [4]. Tab. 2 contains the received dependences of an indicator of acidity of the active centres by the nature of central element and number of the adsorbed water molecules (hydration number $n_{\text{H}_2\text{O}}$).

Tab. 2. The results of calculation of parameters of acidity of the active centres of oxides' surface

Active centre	θ	pK_a^0	ΔG , kilo joule/mole
SiO_3OH	-1,39	11,85	67,58
$\text{SiO}_2(\text{OH})_2$		10,92	62,28
$\text{SiO}(\text{OH})_3$		10,00	57,03
$\text{Si}_2\text{O}_5(\text{OH})_2$		9,23	52,64
TiO_3OH	-1,85	11,29	64,39
$\text{TiO}_2(\text{OH})_2$		10,05	57,32
$\text{TiO}(\text{OH})_3$		8,82	50,30
$\text{Ti}_2\text{O}_5(\text{OH})_2$		7,96	45,40
AlO_5OH	-1,35	13,90	79,27
$\text{AlO}_4(\text{OH})_2$		13,01	74,20
$\text{AlO}_3(\text{OH})_3$		12,11	69,09
$\text{Al}_2\text{O}_9(\text{OH})_2$		13,36	76,19
FeO_5OH	-1,48	13,74	78,36
$\text{FeO}_4(\text{OH})_2$		12,75	72,71
$\text{FeO}_3(\text{OH})_3$		11,78	67,18
$\text{Fe}_2\text{O}_9(\text{OH})_2$		12,98	73,94

Approximation of the received dependences has led to the following linear equations: $pK_a = \theta \cdot n_{\text{H}_2\text{O}} + pK_a^0$. It has appeared, that the free member pK_a^0 has real physical sense of an indicator of acidity of the waterless active centres at $n_{\text{H}_2\text{O}}=0$. The calculated tangent of a corner of an inclination of direct dependence $pK_a = f(n_{\text{H}_2\text{O}})$ to an axis of abscises θ is the value for which the acidity indicator pK_a decreases at adsorption of one water molecule on the active centre. It is possible to confirm, that value θ characterises the degree of increase in acidity of the active centre in process of growth of hydration

number, and it increases among Al^{3+} (-1,35) $< \text{Si}^{4+}$ (-1,39) $< \text{Fe}^{3+}$ (-1,48) $< \text{Ti}^{4+}$ (-1,85).

The linear dependences $\text{pK}_a = f(n_{\text{H}_2\text{O}})$ for superficial active centres TiO_2 are resulted for example on fig. 1.

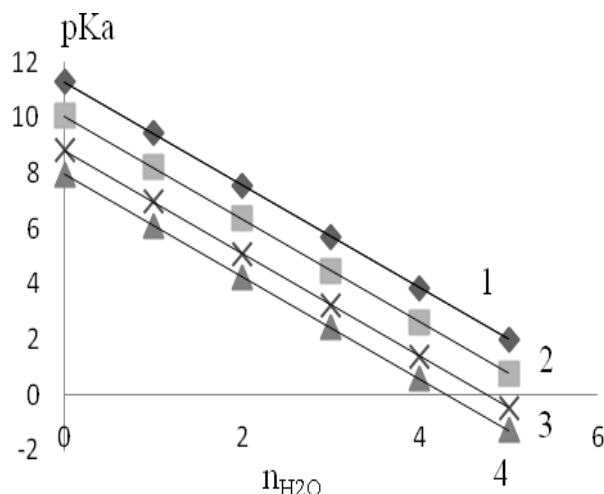


Fig.1. The dependences of change of pK_a active centres: 1- $\text{TiO}_3(\text{OH})$; 2- $\text{TiO}_2(\text{OH})_2$; 3- $\text{TiO}(\text{OH})_3$; $\text{Ti}_2\text{O}_5(\text{OH})_2$ on hydration number $n_{\text{H}_2\text{O}}$.

5. Discussion & Conclusion

The received values of the constant and free Gibbs's energy by the reactions of deprotonation of the waterless active centres show, that acidity of all types of the active centres increases among $\text{Al}^{3+} < \text{Fe}^{3+} < \text{Si}^{4+} < \text{Ti}^{4+}$ depending on the nature of the central element. The acidity of the isolated centres grows at increase of quantity of OH-groups from one to three, forming the active centre. The vicinal superficial centres $\text{Si}_2\text{O}_5(\text{OH})_2$ and $\text{Ti}_2\text{O}_5(\text{OH})_2$ have the greatest acidity from all spectrum of the researched centres. At the same time the vicinal centres $\text{Al}_2\text{O}_9(\text{OH})_2$ and $\text{Fe}_2\text{O}_9(\text{OH})_2$ are characterised more likely by the basic character and also by values of free Gibbs's energy deprotonation of reaction, which are in 1,5 times greater.

The calculated data show, that the acidity of the active centres grows at increase in quantity of the adsorbed water

molecules at surfaces for all oxide disperse materials, and is will be co-ordinated with conclusions of authors [2,5].

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ANALYSIS OF RESEARCH TRENDS ON BENEFITS OF IMPLEMENTING INTEGRATED PROJECT DELIVERY (IPD)

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Abstract

Projects have different conditions, objectives, and features, and accordingly selected contractual models for them are also different. Contract models, besides being effective on different features of the project, have a vital role in its success too. In recent years, various models of types of contracts have been used by employers/clients, consultants and contractors, but because of lack of integration of stakeholders due to fragmentation in contracts, it is appropriate to codify a modern approach to contracts as Integrated Project Delivery (IPD). The benefits of using IPD have been considered by professionals in the field of construction in a number of countries. In this research, the trend of studies in the field of benefits of IPD has been analyzed through a comprehensive literature review. Collected articles were investigated by using qualitative analyses, and finally by using descriptive statistics. The results are presented in the form of statistical tables and diagrams. The purpose of this analysis is to give researchers a better view of available sets of comments of the benefits of applying this executive system and will underlie future studies to improve contract models. Awareness of the obtained benefits of implementing IPD in different parts of the world results in more familiarity of construction practitioners and may assist in improvement of construction conditions significantly.

Keywords: Integrated Project Delivery, IPD, Benefits, Modifications of Contract Models, Trend

1. Introduction

In the traditional form of contracts, construction and design groups act separately. This separation results in several changes at different stages of project life cycle [1]. It can be stated that in today's world, because of complexities of the construction industry, the traditional form of contract has resulted in increasingly high expense to project stakeholders. On the other hand, realization of project objectives, based on predicted conditions, is very important [2]. Integrated Project Delivery (IPD) is a project delivery approach, which integrates people, systems, business structure and uses experiences and insights of all

participants in optimizing project results, enhancing value for owner, reducing wastes and increasing productivity at all stages of construction [3]. IPD method has six features that have significant differences with tradition method of project implementation, including: 1) Multilateral contract: it is a contract that includes all project stakeholders. 2) Sharing risks and rewards: this feature results in increased motivation. 3) Initial presence of key stakeholders: it causes creating understanding and reducing claims at initial stages, and consequently minimizes changes. 4) Common decision making and supervision: it will increase the chance of project success. 5) Sharing

responsibilities among key stakeholders: it results in active presence of stakeholders at all stages of project life cycle. 6) Developing project objectives commonly to meet all objectives of project stakeholders: it is one of the most important criteria of measuring project success [3].

Studies have shown that this method is usable for any type of project, but as this method has not been implemented widely, this hypothesis is not approved yet [4]. In some projects, because of lack of sufficient knowledge, using IPD has not been implemented. In reviewing most projects in which IPD has been implemented, the IPD contract model is the results of changes that were made in traditional project delivery model, and organizing project team was such that time reduced and performance improved, and risks for all stakeholders minimized, and finally a win-win result is obtained for stakeholders [5].

Among the IPD objectives, there is more coordination and trust building among team members to predict project results at initial stages. For that, some tools are applied to improve information sharing process. Also, these tools, by creating better coordination in different systems during project life cycle, result in promoting energy sustainability and efficiency [6]. In order to implement IPD properly, architectural, engineering, and contract teams will also need full familiarity with this method [7]. Several successful projects have benefited IPD at different stages, but because of several reasons such as novelty of this method, lack of sufficient familiarity, governing laws in countries at private and public section, etc. its implementation is still slow [8, 9].

Till now, there is no research in the field of the trend of studies of benefits of IPD implementation. Therefore, in this research, different statistical tables and diagrams will show the trend of benefits of using IPD in different countries and during several years. Obtained statistics and results and presented analysis in this research, in the field of future strategies and using benefits of IPD, will create an opportunity for researchers for further development of this newly born knowledge.

2. Literature Review

In any system of project implementation, contract is very important, and it is known as contract management [10, 11]. For example, in the mid-twentieth century, conventional contracts were used [12]. Despite construction industry complexities, during years after that, other implementation systems were also created [13, 14]. But available systems did not have the required capability of creating interaction among different stakeholders in projects. Therefore, investors face several problems such as increase of various unnecessary expenses. For example, a part of these expenses were due to construction inconsistencies and duplications. Through integrating different stakeholders in the project by IPD method, available conditions can be improved significantly [1].

Recognizing benefits of applying IPD, causes creating motivation among construction industry investors for better selection of contract implementation system, because IPD can result in forming a contract among owner, design team, contractor and other key participants. IPD method allows owner, contractor, architect, engineer, commercial contractors, and consultants cooperate during the whole period of the project [2].

Managers, end users, contractors, and suppliers present there from the beginning of design, and decisions are determined from the beginning while they are clear, transparent and reliable. In many cases, changes are specified in prior to construction, in which the designers will state their comments about consequences of decisions. Through that, risks and rewards are shared in balance among project team members along project life cycle [1].

Among important benefits of implementing IPD is taking advantage of knowledge and skill of each of team members, which are usable during project life cycle. Responsibility of IPD implementation should be assigned to the most capable team member, and all selections should be completed based on the best results for project. Among other important cases, are sharing project information among construction and design team from the beginning of the project, which results in reducing many problems during project implementation [15]. Proposing effective sessions with the presence of all stakeholders, causes significant influence on decisions and integrated communications. Meanwhile, attention of team members is evaluated, which itself is one of the important factors for project success [7]. Reviewing key problems and their priority in order to maintain high standards of quality in projects is also among other achievements of such information sharing, and certainly is associated with reduction of risks, errors and extra expenses, while it increases profits for the project. Of course during these sessions, behavior of team leader is very important and effective [16].

According to conducted studies and comparing IPD with traditional methods, the results show that there is significant

improvement in performances, for example in enhancing the speed of projects delivery. The IPD emerging system with proper performance can be an appropriate guidance in final decisions in choosing a delivery system for shareholders [17]. Construction contracts are very important in success of projects, but performance of current contracts is not satisfying [18]. This issue raised that despite of importance of changing contracts, why speed of IPD implementation, as a valuable approach, is not very satisfying? Reviewing the trend of benefits of IPD refers to the high value of this method.

3. Research Methods

Research methodology in a scientific study is to define the process of regular searches to achieve a given and particular situation [19]. In this study, the literature review method is used as a qualitative method to analyze research trends on benefits of IPD implementation in different parts of the world. In such studies, data are measured by tools such as taking notes, cards, tables, etc. which is considered as qualitative studies [20]. In order to facilitate conducting such qualitative analysis, the Nvivo software has been used. Then, through searching by several keywords, 156 general articles in the field of IPD were investigated. Among the reviewed set, 55 articles investigated benefits of using IPD. In the next section, obtained data are classified, and the obtained descriptive statistics are extracted as tables and diagrams.

4. Analysis & Results

In analyzing the studies that review trends of an issue, data classification based on various criteria is common. Such articles describe and study changes made in a special field or profession on a certain time period [10, 21]. On the other hand, in the

field of construction, because of vastness and complexity of different factors, various classifications can be proposed. But what the researcher proposed was considering general and verifiable issues. Therefore, the following presented summary was analyzed. At first, in order to collect articles, as presented in the Table 1, several scientific databases were investigated, which the number of found articles in each of them is shown.

Database Name	Number of papers
ASCE	30
ScienceDirect	14
AIA	4
SMPS Foundation	1
Dissertation	2
Civilica	1
Taylor&Francis	3

Table 1: Databases and the number of found articles in each

Some of these databases, because of specialty of the issue, include more articles. Such as ASCE database, which has more articles with more variety in different years. All investigated databases are among the most prestigious scientific ones and are popular among researchers. The studies conducted the extent of IPD are in different fields. IPD has been implemented in health projects more than other types.

Following, dispersion of articles during different years is presented in the Table 2.

Continents	Number of papers	Years
America	2	2007
-	0	2008
America	4	2009
Europe, America	6	2010
Africa, America	5	2011
Asia, America	8	2012
America	8	2013
Australia, Europe, Asia, America	18	2014
Asia, America	4	2015
-	0	2016

Table 2: Continents presenting articles in different years

According to the information provided in this table, in the early years, the number of articles in this field was less because of lack of information from real cases having IPD implementation experience. It seems that in 2008, the benefits of this method were not investigated in any research. But by the progress of studies in recent years, especially in 2014, significant growth in the field has occurred. Researchers such as Lee, Tommelein and Ballard in 2013 emphasized this point that between 2009 and 2013, the IPD was starting to be evaluated in other countries in addition to the USA [22]. Researchers such as Chunyan MA, Xiaodong LI and Yangyang MENG in 2014 emphasized that after coming up with some initial instructions for IPD implementation in the USA in 2007 researchers in Asia started investigating various dimensions of IPD, especially its different benefits, and to study conditions of its implementation in their own countries [23]. Researcher such as Al Subaih emphasized that in 2015, East Asian countries and Middle East countries also published cases of implementing IPD [24]. Sometimes these cases were at stages of projects maintenance. The obtained results in these cases were significant. In the Diagram 1, different applied domains in the field of

construction were considered by the researcher.

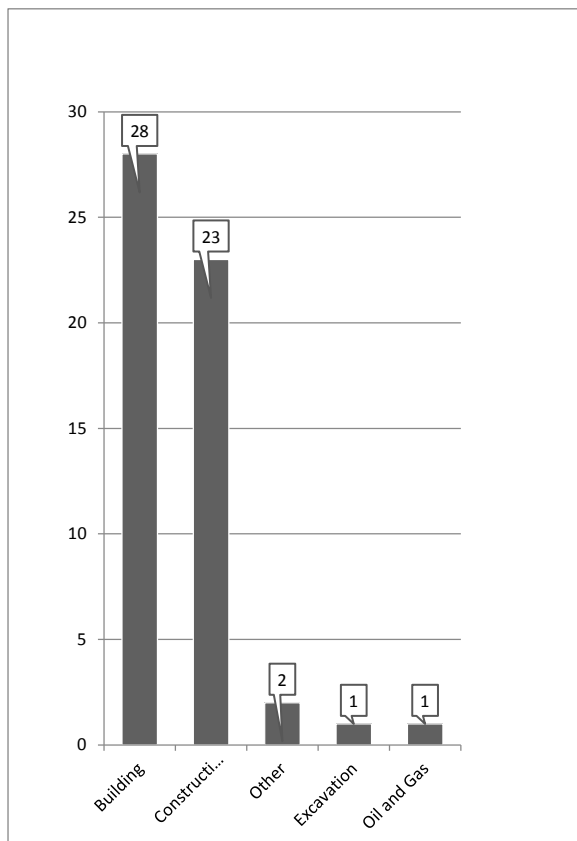


Diagram 1: The number of articles focused on different construction sectors

This diagram shows that, in terms of application domains, building sector has been the focus of most of the research articles. Construction industry, despite high volume of application, has less share in studying the benefits of IPD and its application in different sections. Presence of oil and gas industry as well as excavation is also notable in this diagram. It indicates high capabilities of IPD to be implemented in various industries.

In the Diagram 2, articles are evaluated from the viewpoint of studies focused on case studies or theory-based research.

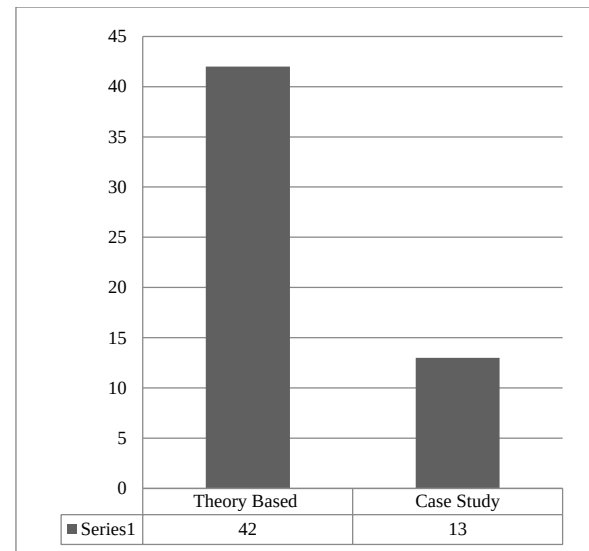


Diagram 2: The number of articles on IPD benefits in case studies and theory-based researches

Case studies articles are important in that their results are adaptable with other similar projects. Most of the case studies have been implemented in the USA. Since this method is emerging and in order to implement it, special conditions and regulations are required. Theory-based articles focus on identifying benefits of IPD implementation. Some of the proposed benefits inherently are raised in the IPD itself, and some others are obtained through comparisons with other methods. But what is very special are the benefits extracted from the case studies. In studies based on case studies, besides implementing IPD in a sample project, its benefits are also presented, including reducing costs and time.

In the Diagram 3, articles with quantitative data analyses are presented.

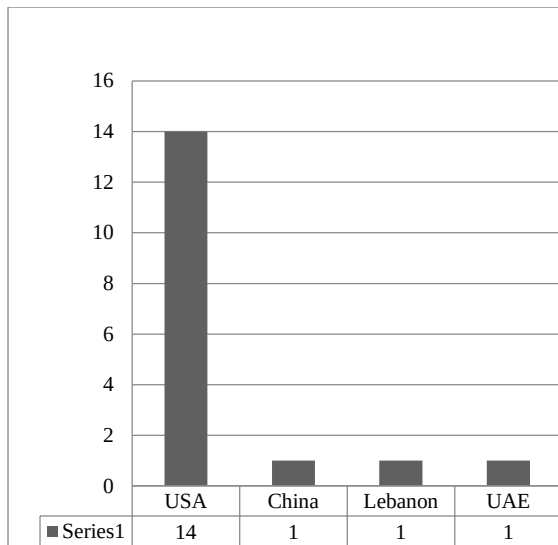


Diagram 2: Articles with quantitative results

This diagram illustrates that studying quantitative results to present correct solutions of IPD implementation for project stakeholders are important. According to high volume of articles on implementation of IPD in the USA, extracting quantitative results was also more in this country. Countries such as Lebanon, Emirates, and China also by comparing IPD with other methods, found quantitative results. Such results help investors to choose the correct method of implementation.

What can be seen in available articles is that no one have specifically analyzed the research trends of benefits of IPD; however some have considered what benefits are taken from IPD implementation in different case studies [25]. This analysis has identified that some countries have different rules in implementing IPD. The USA has made significant progress in this field mainly through case studies. A small number of studies from other countries have also analyzed benefits of IPD implementation on maintenance of projects. Collecting quantitative results of IPD benefits is also an effective and useful step toward helping the construction investors in selecting

proper contract type as one of important benefits of IPD is sharing rewards and risks in projects.

Researchers, in investigating the trend of IPD benefits, have tried different techniques. Some raised inherent benefits of IPD through theoretical studies. The others investigated benefits resulted from real case studies implemented around the world. The mentioned cases are presented in the following table:

Data Source	Benefits
Theoretical Articles	Inherent benefits, including: reducing workload, more usage of information, less request, reduction of construction time and cost, increasing safety, optimal management of material, early order of material, and reduction of tensions [26]. Benefits that involve economic, cultural, social, and political aspects [1].
Case Study Articles	Quantitative benefits extracted from real case studies, including: reduction of change orders [2], saving costs [6], better performance of risk management [22], accelerating project delivery [17], and improving quality [27].

Table 2: Type of data sources investigating the IPD benefits

All these data sources highlight the need for more in-depth exploration of the IPD implementation benefits; as well as restoration and updating the available laws especially in the early project planning and design stages.

5. Discussion & Conclusion

In this research, an analysis of the research trends on the benefits of implementing IPD was studied. Efforts to create an IPD system started from the 1990s, and which in 2007 resulted in the presentation of the IPD system. In 2014, the highest volume of studies about benefits of the system had

been conducted [7]. The greatest number of articles has been written in the USA. Most of the studies have been case studies implemented in the USA. Only few studies have been accompanied with quantitative data. The main application of this system has so far been in the field of construction, particularly the building sector. From analysis of the studies to date, it can be seen that most utilization of the IPD in the field of building has been in the health sector projects. Only a small number of studies have focused on the benefits of IPD. In addition it can be concluded that most of the articles written in countries other than USA, have studied the benefits of IPD from a theoretical perspective and have not come up with empirical data.

The governing laws of countries, especially in the public sector, are considered among barriers of proper implementation of IPD. Cooperation and effective team work are among the most important principles of implementing IPD is. China, in addition to legal barriers in implementing the IPD, was faced with problems of team work and lack of efficient appropriate culture in this field. Researchers have attempted to formulate guidelines in the field of developing this culture in order to create proper motivation for coordinating team work, interaction and information sharing [23]. African researchers, such as Ghana, investigated the benefits of IPD in projects that need a high degree of team participation. Also, they considered that integration done in group work, are very effective in increasing efficiency of working teams of projects, and leads to more successful delivery of projects [28]. In some case studies, despite applying IPD, because of lack of sufficient knowledge of stakeholders about its proper implementation instructions, desirable outcome is not obtained. Case studies offer

valuable experiences to contractors and owners in the field of mutual participation. But in some projects, the IPD has not been implemented at all stages. For example, in some, it has only been used in the post-construction stages. It is recommended to explore IPD effects in all project life cycle stages rather than a specific phase.

In this research, articles in the field of benefits of IPD were reviewed. In total, 55 articles, in which benefits of IPD have been discussed, were studied and data extracted. Researchers such as Gerber et.al in 2010 emphasized this point that investigating benefits of IPD is very important [2] as it can simply enhance project implementation processes. Among the most important barriers that are problematic in different stages of projects, are changes during implementation due to lack of required coordination among project stakeholders. But desirable results of cooperation through IPD, eliminates or minimizes changes and claims, and finally, results in achieving projects within estimated budgets and time constraints. What is obvious in the conducted studies reviewed is the attention and interest of the professional community to use modern methods such as IPD has been increasing.

The results of this study provide possible lines for future research to investigate the benefits of the IPD approach in a more comprehensive way, particularly in projects. Since implementing the IPD method needs reviewing and codifying different contracts and codification of a multilateral contract, researchers should investigate the field of creating these changes according to needs and conditions of different countries. Governing laws in countries should be investigated by researchers to evaluate and review limitations available in these laws to implement IPD. According to the research

to-date, governing laws in public sections are considered as serious barriers for effective implementation of IPD in most countries. Moreover, investigating how to implement IPD and its processes should be proposed according to available equipment and capabilities of each countries based on their culture and region. Among other possible future studies in this field, is studying the benefits of IPD in projects that use Building Information Modeling (BIM). It is because BIM is a tool for better realization of IPD. Research has shown that IPD and BIM, in design and construction processes, have significant and positive effect on costs and profit, planning, investing, safety, productivity, and communication [29].

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EXAMINING THE PRODUCTIVITY IN THE NZ CONSTRUCTION INDUSTRY

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Abstract

Construction productivity is a primary driver for economic growth. Understanding the factors that contribute to productivity will lead a country to prosperity. The trend for construction productivity in New Zealand is that it has remained stagnant over the past 12 years. For an accurate assessment on construction productivity and the factors contributing to it the elements and steps taken throughout the construction process need to be assessed. Through a literature review of both international and New Zealand based papers establishment of the main contributing factors were narrowed down. Primary qualitative data collection was then undertaken using experienced construction Project Managers and Site Managers working within the construction industry to provide their thoughts on the factors established as part of the literature review. The results from the interview analysis provide evidence for several areas of concern in relation to construction productivity. For some of these contributing factors the issues appear systemic and will require a paradigm shift if we are to influence the industry, for others small initial design, through planning and procurement and into execution.

Keywords: Construction Productivity, Supply Chain, New Zealand

1. Introduction

The construction industry in New Zealand is a \$30 billion plus industry, generating approximately 6% of GDP [1]. Construction productivity is a vital part of any countries' economy. As numbers of studies have been commissioned to look for ways to improve productivity and hence the strength and level of confidence in a country's economy [2]. However, construction is a large industry with a lot of moving parts, leading to the difficulty when it comes to assessing productivity. Meanwhile, there is no defined method for measuring productivity as there are many factors to consider [3, 4]. The purpose of this paper is to convey the evidence on the performance of the construction industry in relation to productivity. Productivity will be reviewed in terms of how productivity growth has performed to date and how construction industries productivity is now. The paper also includes comparisons between the New Zealand construction industry with other countries' industries within The Organization for Economic Cooperation and Development (OECD).

Various factors of construction productivity should be considered when looking at productivity as a whole in the New Zealand construction industry. These factors include, but are not limited to: employment skill levels, supply chain, design, labors costs, management and project planning.

2. Literature Review

Productivity in construction is a dynamic and wide ranging. Construction itself is board and covers the building of infrastructure, housing and commercial builds [5]. The construction is a vital part of any growing economy contributing 6%, 7.6% and 9.7% to the New Zealand, Australian and European GDP respectively [1, 4, 6]. However, uncertainty in workloads leading to ineffective planning and reluctance to invest in staff and resources has had a substantial impact in New Zealand's ability to develop growth in productivity within the construction industry [2, 7]. In addition, New Zealand is an isolated country with the exception of Auckland, has a relatively sparse population spread. This isolated and

geographical separation provides difficult challenges when it comes to supply chain management [2, 4], which will have an effect on profits through transport or material costs [8].

3. Research Methods

A qualitative research has been conducted to collect primary data on the topic. The qualitative approach focuses on the subjective assessment of attitudes, behaviour and opinions, which includes smaller samples, but in more depth, resulting in deeper thoughts and opinions that can only be reached through prolonged analysis and discussion [9]. The method for data gathering was through one on one interviews, all interviewees that took part in the research have experience in excess of 10 years within the construction industry and were willing participants. For the research gathering, 3 site managers and 2 project managers are interviewed, which is an acceptable sample size for such research [10]. All the interviews are recorded and summarized into some brief notes. After that, post analysis of the recordings is provided and the results are reported in this paper. However, such method is limited in factual data production. The results only offer an interpretation of what is being said, which is still fundamentally in the mind of the researchers. Otherwise, such method can benefit the research by providing words and not just numbers as data analysis. It aims to answer the questions of 'how', 'what', 'where', 'when', or 'why' instead of the 'how much' and 'how many' from quantitative research.

4. Analysis & Results

The opinions of the interviewees are summarized as followings.

- From the comments received regarding complex details and nothing being typical in building design, it is commented that many buildings and developments are seen as 'one-offs' that is to say there is not much in the way of modular construction in New Zealand.

The vast range of details and designs coming out into the market place lends itself to inefficiencies as each build is unique. Therefore, the isolation from design developments being made overseas coupled with our smaller population base is contributing to the lack of repetitiveness of details and proven systems that is occurring elsewhere in the world.

- The supply chain in New Zealand for regularly used building materials and fixtures is adequate. Construction sites are able to access the materials they require for conventional construction works without long lead times. Although the literature conveys this as a major issue on site it was not something that came through as being a major issue during the interviews, but it does form part of the problem. There were issues mentioned relating to the control mechanisms in place for the construction market in terms of price and availability of some products.
- A lack of skill for site based personnel was perceived by all participants in the interviews. There is a shortage in the skilled labour and this has a direct effect on productivity on site.
- All participants in the qualitative research were aware of labour costs associated with their projects. This is a good sign as it shows there is a connection between the costing of the job and the project team that undertaken the project itself, however it appears this is the extent of that connection. Otherwise, with all participants in the interviews agreeing the costs for labour and the resulting productivity were some ways apart, it links back to the skills and training section from the research undertaken. With no culpability on estimating staff currently observed from the responses gathered as part of the qualitative research there seems to be an area for improvement, at least in the reporting of trades and productivity witnessed.

- A vast amount of planning goes into any construction project to help make it more productive, but from time to time the planning can go out the window if there is a breakdown in communication and a crucial material is short onsite. As was mentioned by the interviewees many of them have relied on their relationships and history with particular suppliers to 'make it happen' and have an order on site at a fast turnaround. This works well for the suppliers too.

5. Discussion & Conclusion

The research contribution as a result of achieving the research aim can be found in the form of actionable bullet points listed below.

a. Design

- More collaboration is required between designers (architects) and sub-contractors.
- The use of modular construction and standard details for certain areas – mainly regarding roof construction flashings and details should be increased.
- Designers should only take a workload they can reasonably handle and service.
- Simplifying or developing standard construction details for certain areas of the buildings.
- Simplifying or developing standard construction details for certain areas of the building.

b. Supply Chain

- The supply chain is reasonably good for basic building materials; however, more clarity is required on the costs New Zealanders are paying for the materials compared to markets such as Australia.
- Make it easier for new materials to be tested and BRANZ approved for integration into New Zealand market.
- Training would be beneficial for construction site management on motivational techniques and fundamentals of motivation.
- Technology uptake needs to be more wide spread with regards to building

information modelling (BIM). Training, advertising and buy-in from consultants will save time on site regarding productivity.

c. Labour

- A more robust method of recording labour rates and output is required for some businesses to get a better idea of market rates and output expectations.
- Closer collaboration between site and tender teams is needed to check time frames.
- Labour reporting from job to job and site team to site team would be advantageous for future jobs and team member requests.

d. Project Planning

- Office teams need to be collaborating with the site teams for program durations and buildability concerns.
- Construction companies need to encourage their site teams to note down issues they encounter through the job.
- Construction companies need to encourage their site teams to note down issues they encounter through the job.
- Architects and designers need to review the lead times for items they specify in their design.
- Risk registers need to be setup at the tendering stages to outline areas where supply or other construction risks may lie.
- The Government should look into areas of construction that are providing constant productivity issues, such as windows and glazing, and report as to what reasons there could be for parts of the essential construction products to have supply chain issues.
- Suppliers of New Zealand building products need to be monitoring the construction industry more closely to recognize fluctuations in demand, ensuring product is stocked accordingly.

e. Skill, Training and Motivation

- New Zealand business need to be more aware of training available for their staff, and ensure their staff are aware of training options open to them.
- More collaboration between employers and employees is required so that employees can voice their wishes with regards to training and employers can see that it happens.
- Family trees from sub-contractors and relative experience need to be recorded at tender time.
- An investigation into the standard of the apprenticeship programmes in New Zealand may be required with more advertising and exposure to trades as a good career option for youth.

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COMBINING SMALL-SCALE WIND AND HYDRO GENERATION

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Abstract

Abstract— Renewable energy is a useful and significant source of electrical power, and its use is only increasing as the availability of fossil fuels dwindles. This work seeks to make renewable energy more reliable, cost effective, and accessible by exploring a different energy combination system to that currently applied to wind and hydro power. Instead of the usual electrical combination of wind and hydro generators, this project involved combining a water and wind turbine mechanically, before driving an electrical generator. This new combination system was modeled and optimized in MATLAB, using a direct combination system commonly found in multi-engine helicopters. The system was found to operate satisfactorily, however it is mechanically more complex than current, electrical combining systems. There is potential for further research in the areas of pump-hydro storage and using a water pump as a turbine, both as an extension of this project. Research was undertaken regarding wind and water resource availability, and the turbines were chosen with these taken into consideration. Various combination systems were explored, including torque and speed split mechanical combinations, conventional electrical combination, and using a modified switched reluctance generator as a method of electro-mechanical combination.

Keywords Renewable Energy, Wind Turbine, Hydro Turbine

1. Introduction

In traditional hybrid energy system energy obtained from different renewable energy sources is collected at a common DC bus [1]-[7] or these sources are connected electrically through power electronics interface [8]-[11] to extract maximum energy from the sources and for optimal use of harvested energy. In contrast to the traditional system of connecting renewable energy sources, this work involves designing and modelling a renewable electricity generation system whereby a small wind turbine and small water turbine are mechanically combined to drive a single generator.

All renewable energy applications are very dependent on site geography and resource availability. The available resources were researched and settled before choosing turbines and generators. Following that, various methods of combination are researched and discussed. The chosen system is then implemented using computer simulation software, and the output from the simulation is used to compare with

existing systems of combination. Finally, conclusions and final recommendations are drawn, and future developments are explained.

2. Application Context

The use of renewable energy technologies, both large and small scale, is largely dependent on the geography in the area of application. In order to simplify development, the project is directed towards a small-scale implementation. Typically, this will involve a rural property or lifestyle block, where the land owner has access to a source of flowing water, and steady wind. Based on an average household power consumption of 8000 kWh per year, this system will aim to generate approximately 1 kW on average. There is, however, argument for considerably less than that, because with some care and attention to energy efficiency power usage could realistically be half of that. Lifetime of the system is also considered while choosing the components and for this study it will be taken as 10

years. A factor of safety of at least 10 was applied when selecting or designing components.

Small scale renewable energy applications are inherently specific to the site they are implemented on. This makes it very difficult to research and design a system that can be generally applied. For this reason a suitable site has been assumed, with a source of hydro energy and wind energy in close proximity. Examples of such locations in New Zealand include valley floors facing into the prevailing wind (typically westerly), and mountain ranges such as the Ruahine and Tararua Ranges. Exposed coastal areas with streams could also suit. The specific parameters assumed for this study are:

- i) Water flow: 20 litres/sec, 5 metres head
- ii) Wind: 5-6 m/s on average, feasible to place a small wind turbine in clean air.

The wind speed was chosen based on information from NIWA [12]. Figure 1 illustrates the available wind resource for the whole of New Zealand. The water supply is deliberately a small estimate to maximize the applicability of this project to a wider selection of sites.

3. Wind Turbine Selection

3.1 Model Description

The Background choice of a wind turbine was between three possibilities, see table 1. The model given in [13] was analyzed and the following equation giving output torque as a function of shaft speed ω , was produced. Note that this works with normalized speeds and torques (i.e. expects ω in the range of 0-1 (1 being the rated wind velocity for the turbine), and gives the output torque in the range 0-1 (1 being the stall torque).

$$Torque = 0.0608\omega^3 + 2.1288\omega^2 + 0.5264\omega + 1.011 \quad (1)$$

With this equation in hand, the overall model for the wind turbine required for the

project was produced. It can be broken down as shown in Figure 2.

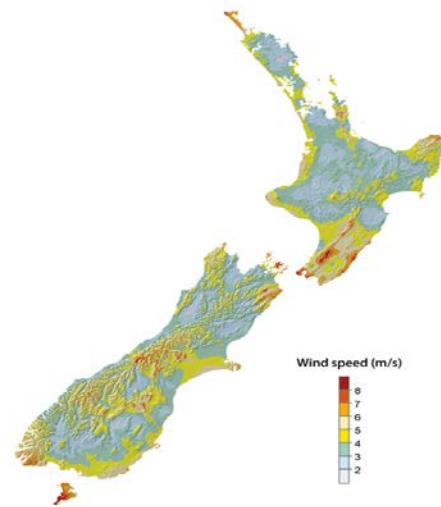


Figure 1 New Zealand wind resource. [12]

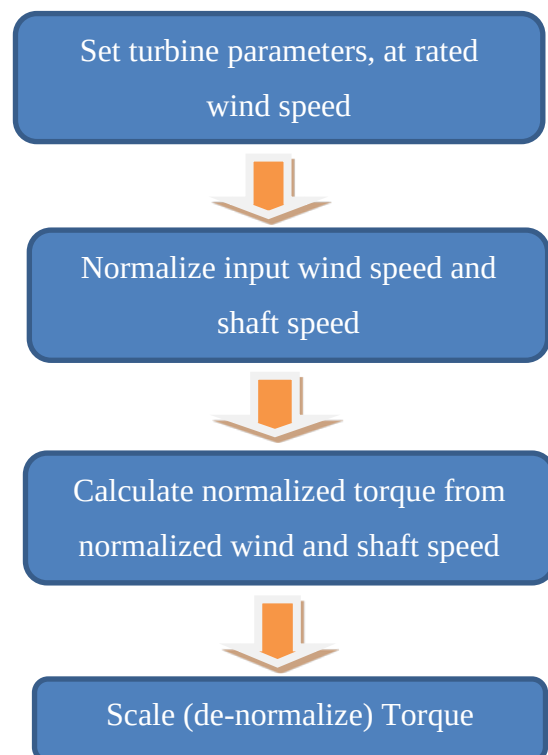


Figure 2 Wind turbine model

Table 1 Wind turbine design matrix

Turbine Model	Rotor speed	Torque	Starting Torque	Self-starting	Reliability/Durability	Efficiency	Power location
Three blade HAWT	High	Low	Low	Yes	Fair	High	Top
American wind mill	Low	High	Very High	Yes	Good	Fair	Top
VAWT	Low	Mid	Low	No	Poor	Fair	Ground

Table 2 Hydro turbine design matrix

Turbine Model	Head	Flow	Scale	Reliability/Durability
Overshot	Small	Medium to high	Pico to small	Good
Undershot	Very small	Medium to high	Pico to micro	Good
Pelton	Medium to high	Low to medium	Micro to large	Good
Turgo	Small to high	Low to medium	Pico to large	Good
Crossflow	Small to medium	High	Micro to medium	Good

Prior to running the wind turbine model in the main combiner model, it was tested on its own to verify its accuracy. In figure 3, the wind turbine output is illustrated for wind speeds of 1-6 m/s.

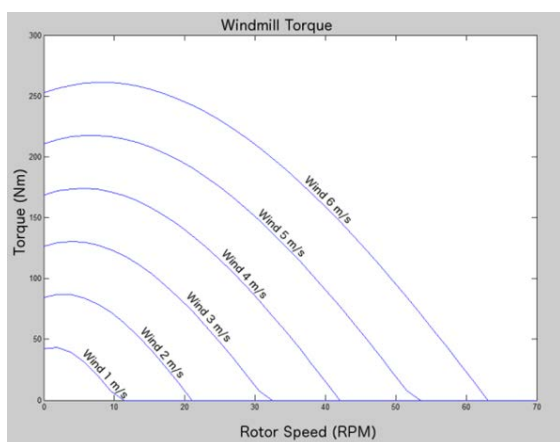


Figure 3 Wind turbine characteristics

4. Hydro Turbine Selection

Several different types of water turbines and wheels were considered, see table 2 for a comparison between these turbines. The specified pressure head of 5 meters ruled out undershot and crossflow, and made overshot undesirable because of the physical size. Therefore, Turgo type of turbine as shown in Figure 4 was thought to be suitable. Turgos have the advantage of being self-cleaning, due to non-recirculating water flow inside the turbine housing. The water jet enters the turbine runner from above and exits below, so the used water does not interfere with the incoming jet. They are Tasy to construct, and relatively cheap. Another significant factor in the choice of water turbine was the availability of mathematical model of the turbine that could be implemented in

MTALAB and incorporated into main combination model. Large scale models for both Pelton and Turgo were available however they did not scale well to the very small scale that this project is studying. The discovery of a small scale Turgo model was a contributing factor in the decision. The model used was an implementation of a model found in [14] with the findings validated experimentally, and the described model calculates turgo speed/torque characteristics from first principles, using conservation of momentum. This model can be broken into process flow as shown in Figure 5.

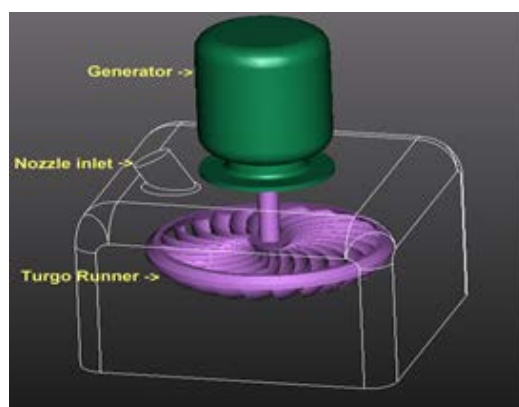


Figure 4 Turgo Turbine

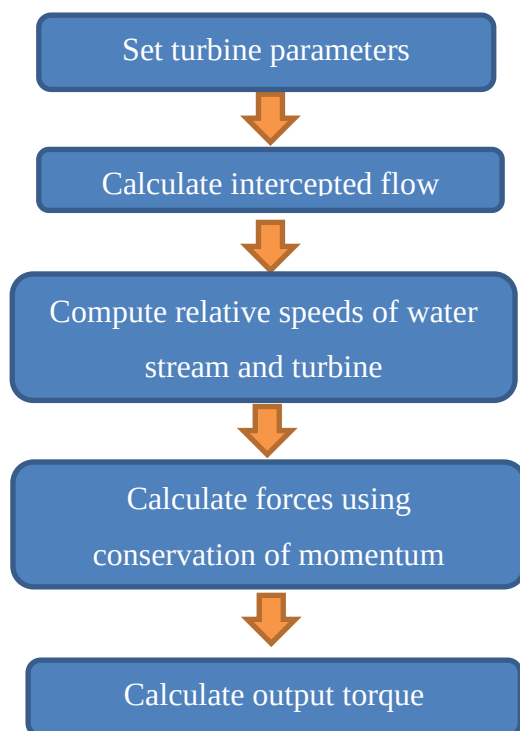


Figure 4 Turgo model

The turbine parameters are particularly important to this model because it calculates from first principles.

5 Method of Coupling

The method of coupling both the renewable energy sources is the most significant part of this work. The possibilities are as follows:

- i) Electrical combining
- ii) Mechanical
 - (a) Constant torque (“speed-split”)
 - (b) Constant speed (“torque-split”)
- iii) Electromechanical

5.1 Discussion

Electrical combination as shown in Figure 6 is the current norm. In this method, a wind turbine is installed separately to the hydro turbine, using separate electrical generators, and their outputs are combined in the electrical system of the installation. The two systems are mechanically independent

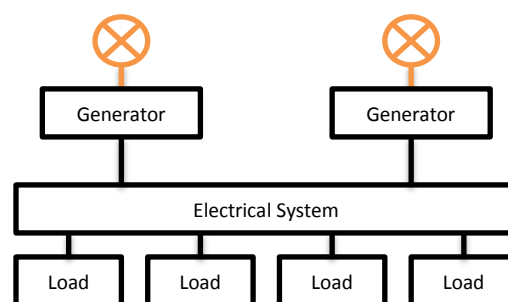


Figure 5 Conventional Electrical Combination

Electromechanical combination is a way of combining the two turbine outputs, and would involve a generator that had two rotors, instead of a rotor and stator. In this case, the two rotors would rotate in opposing directions, against each other. Because they rotate against each other and no torque is applied across the generator housing, the input torques must be equal but opposite. For reasons discussed below, this could be problematic.

If the outputs were to be combined in a purely mechanical fashion, then driving a conventional generator, two variations are

possible. These are constant torque, and constant speed. Constant torque means the two inputs must have equal torques, but the input speeds can vary with respect to each other and the frame of reference. Two methods of obtaining this were considered, using a differential gearbox, and a planetary gearbox. Both of these examples are used in the automotive industry.

A differential gearbox shown in Figure 6 will be immediately familiar to anyone with a working knowledge of automobiles, as they are universally used to supply the engine power to the wheels on either side, and provide an ability to accommodate a speed differential between the driven wheels (required when turning). While in this case the differential has a single input and two outputs, the system works fine the other way. This is evident when your car is up on jacks, and you rotate one wheel, causing the opposite wheel to turn the other way.

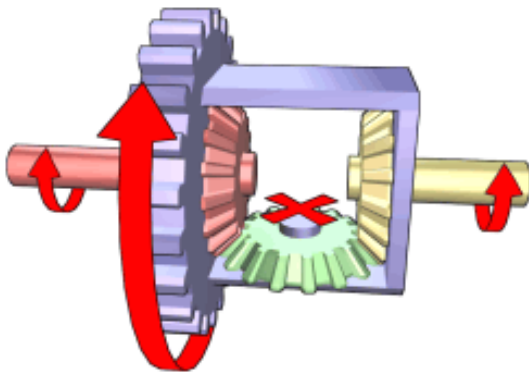


Figure 6 Differential

A planetary gearbox is commonly used in electric drills to reduce the motor speed to a usable speed for drilling, and in some aircraft to reduce the engine speed to one usable for the propeller or rotors. Toyota also uses planetary gearboxes to combine the petrol engine, two electric motor/generators, and wheels in the Toyota Hybrid System [15]. This system acts as both a continuously variable transmission for the petrol engine and electric motors, and as a way of allowing any combination of power flow between the motor/generators, petrol engine, and wheels. While this system works well in

practice, it needs high level supervisory control to coordinate the various power sources and loads, and is quite complex. The main disadvantage to a constant torque method like this is caused by the fact that the speeds of the inputs can vary with respect to each other, but the torques will be constant. If the system has inertia, which any physical system will, then the input speeds may be unstable, particularly if the speed-torque curve of a driving source is flat. This phenomenon is known as hunting, as the power sources tend to “hunt” around the operating point and never settle.

A second disadvantage is that if one source is driving the load, the other’s starting torque will be equal to the driving source (depending on relative gearing ratios, it may be different, but certainly non-zero). The system could be made to allow torque differentials also, but such arrangements generally involve friction (and thus power loss), and a complex mechanism to achieve it. Constant speed means the inputs must have the same speed in order to contribute to the output. Their torque’s add together in the output, and may vary with respect to each other. A common application of this type of drive is in multi engine helicopters as shown in Figure 7. In this case, two or more turbine engines drive the main rotor at a set speed. This arrangement makes it possible for one engine to fail, leaving the remaining operative engine(s) to continue powering the aircraft. A freewheel clutch on each input to the combining gearbox prevents the failed engine from being driven by the operative ones, which could be dangerous depending on how the engine has failed, not to mention the waste of power.

In its most basic form, this gearbox is very simple, with two input gears that both drive a single output gear. Extra reduction may be added if appropriate for the application. The main drawback to this method is that the inputs must have the same speed relative to each other. Also a free wheel clutch is required to prevent power loss to a malfunctioning or slow input. The

advantages include zero starting torque (indeed an input will not be loaded until it reaches the speed that the system is currently operating at), and perhaps most significantly the simplicity. The simpler a system, the more reliable it will be, or it will be easier to make reliable, than a complex system.



Figure 7 PT-6T Pratt & Whitney Helicopter Powerplant

Using the chosen wind turbine, the output shaft must be put through a 90-degree gearbox to pass vertically down to ground level where the hydro turbine and combining gearbox is. As it is expected that the hydro and wind turbines are offset laterally, a total of three 90 degree gearboxes are required, which can incorporate the necessary gear ratios. Figure 8 illustrates the proposed physical system design.

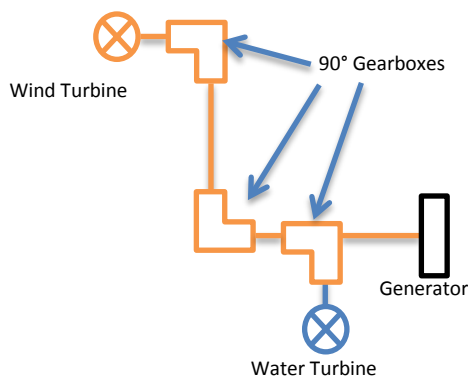


Figure 8 Physical Design

6 Generator Selection

The generator selected for this work is the venerable Fisher & Paykel Smart Drive. It is well regarded for use as a generator, after converting it from its original purpose of driving washing machines. Widely used in DIY small scale generation, they are also

used in some commercial products[16]. However research [17],[18] indicated that the common Smart Drive did not have the required power capacity for this application (peaking in the range of several hundred watts), which seeks to generate in the order of 1 kW. A test rig as shown in Figure 9 constructed by [17] coupled a small turgo turbine to a Smart Drive generator peaked at approximately 800 watts, the limiting factor being the Smart Drive. A more suitable generator (Figure 10) was found, model GL-PMG-1000 manufactured by Ginlong Technologies.

6.2 Modeling

With a rated power of 1kW, and designed for wind energy applications, it seemed a good fit for this application. The datasheet supplied by the manufacturer contained all the information needed to model the generator in Simulink. The graphs as shown in Figure 11 were plotted in an Excel spreadsheet, and a polynomial fit was applied to the points to obtain a system equation relating rotation speed to power, voltage, and torque.



Figure 9 Smart Drive and Turgo [17]



Figure 10 - 1 kw generator

Power generated was given by the equation

$$P(\omega) = -0.0032\omega^3 + 0.6836\omega^2 - 1.52769\omega \quad (2)$$

The torque applied on the shaft by the generator (of course opposing the current motion) is given by

$$T(\omega) = -0.0041\omega^2 + 0.8788\omega \quad (3)$$

The output voltage was not of concern to this project, as it is assumed that the downstream electrical systems will deal with that. Overall power generated is the important part. A MPPT (Maximum Power Point Tracking) controller may be required to maximize the output.

The generator was represented as a torque source in the simulation, taking the shaft speed as an input, and applying a torque to the system that opposed the direction of rotation.

7. Simulation Results

7.1 Windmill

To model the system the windmill had to be modeled. This proved not to be a trivial process because the torque generated by the turbine depended on both wind speed and the angular velocity of the rotor. The first model created (using the Simscape tools in the MATLAB and Simulink software packages), generated a very simple linear speed-torque characteristic. It did not take a direct wind speed input, instead using a stall torque. A rotational damper was used to make the torque reduce linearly as the rotor's angular velocity increased. In water pumping applications (where the American wind turbine is most commonly used) the starting torque is approximately 3 times that of the mean torque requirement when running [13]. This means the torque at the turbine's operating speed is one third of the starting torque.

While the simple, initial model produced a simple linear speed-torque curve, the reality is that it is a curve, albeit a fairly simple one [13]. The wind speed affects both speed



Figure 11 Generator characteristics

and torque. This is an important assumption made in the model that is created. Figure 12 shows the varying speed torque curves for different wind speeds, as modeled. The small kinks at the bottom of the 1 m/s, 3 m/s, and 5 m/s curves are an artifact of the MATLAB simulation.

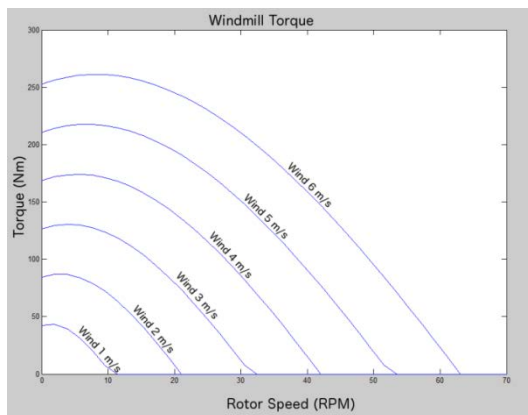


Figure 12 Wind turbine characteristics as modeled

7.2 Turgo hydro turbine

A model for a Turgo turbine in the pico-hydro scale is generated in [14]. This model was implemented in Simulink and added to the already functioning model. No work was done in attempting to optimize those parameters for this project, except for the water head, jet diameter, and turbine radius. The model does not consider windage losses inside the turbine housing. The parameters that were left as is include jet entry angle, water/turbine contact angles, and water exit angle. A 5cm jet diameter was found to produce a flow of 19.7 liters/sec when fed with 5m head water, matching the specifications of 20 liters/sec. The output of the model is illustrated in Figure 13, showing speed-torque curves for heads of 1 to 5 metres, in 1 metres increments.

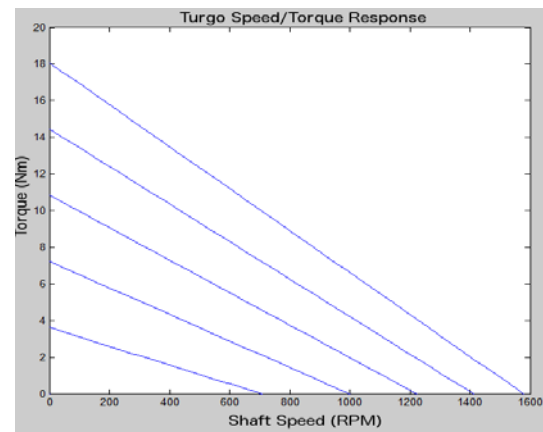


Figure 13 Turgo characteristics as modeled

7.3 Combining system

The “torque-split” combining system was modeled using the SimScape mechanical simulation toolbox, with the Simulink tool bundled with MATLAB. Only the fundamental mechanical blocks were used. The initial modeling was attempted using first principles and a complete mathematical model of the system, using only the mathematical blocks in Simulink. However, this proved very difficult to debug and improve, as every fundamental property had to be incorporated into the model. For this reason, the model was rewritten using the SimScape mechanical blocks. The wind and hydro turbines were each modeled in their own custom code blocks, and each took an input of shaft speed and generated a simulated output torque from the model contained within. Figures 14 and 15 show these custom code blocks within the main model.

The SimScape tools had common fundamental elements all ready to go, such as torque sources, inertia elements, gearboxes, sensors etc. The most significant inertia that of the wind turbine, was found to be 120kg.m², by approximating the wind turbine as a disc, a valid assumption for the solid American Wind pump.

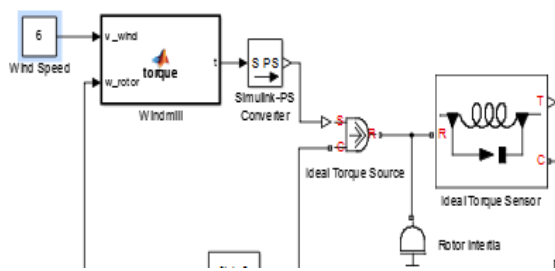


Figure 14 Wind turbine portion of main model

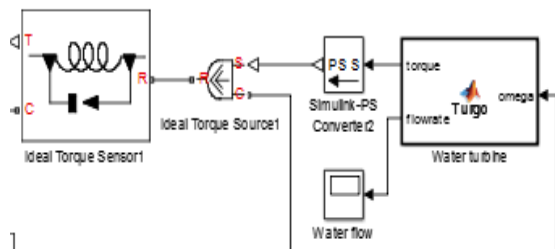


Figure 15 Generator portion, showing gearboxes

A gearbox coupled each turbine to a common shaft that drove the generator. The generator itself was implemented such that it applied a torque opposing the direction of rotation of the common shaft. This torque was determined by the speed of the shaft, using equation 3. This section of the model is shown in Figure 15. The gearbox ratios (1:12 step up for the wind turbine, 1:2 step down for the turgo) were determined by an iterative process of maximizing the power output for rated resource inputs (6 m/s wind, 20 l/s water @ 5m). In doing this, the power output was increased from 600 watts to 1040 watts.

7.3 Results

The simulation results show that the system settled at a steady state within a few seconds, after overcoming the inertias present. Figure 16 shows the power output of the generator over the first 10 seconds of operation. It settles at just below 1040 watts, using rated inputs. Figure 17 shows the power output if the wind source is removed, leaving just the hydro turbine driving the generator. Note that it is assumed a freewheel clutch effectively removes the wind turbine from the system

in such circumstances. Figure 18 shows the power output if the water turbine does not supply any power to the system, assuming a freewheel clutch is fitted on the output of the turgo turbine. The power output settles at 380 watts. This is of interest because it shows that the turbines, when driving together, can operate in a more efficient region, hence the generator is able to produce more power when both are driving together, than the sum of each turbine driving on its own.

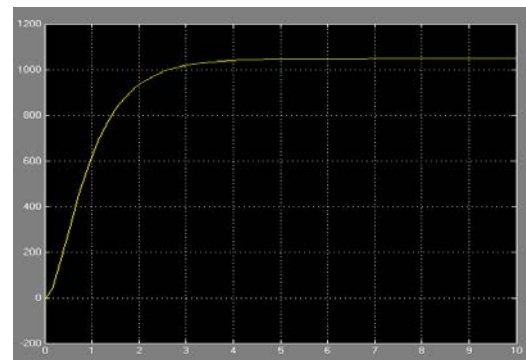


Figure 16 Power output over 10 seconds

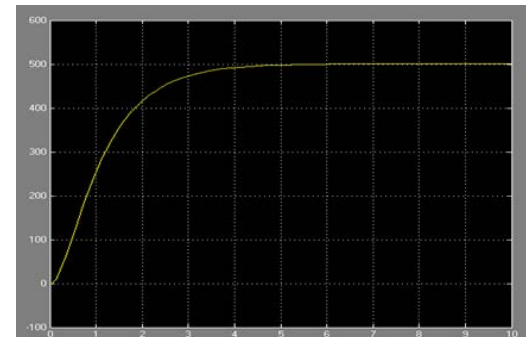


Figure 17 Power output with no wind

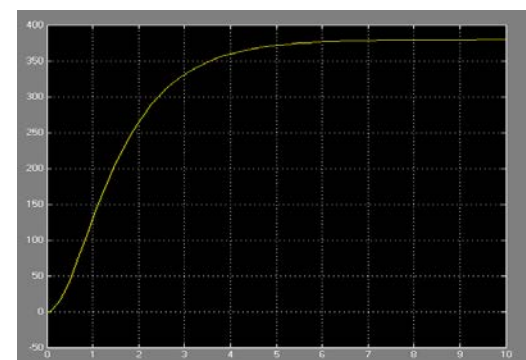


Figure 18 Power output using only wind, over first 10 seconds

8 Analysis of findings (Power Output)

Renewable energy sources are intermittent, especially wind and solar. This means that the system as designed will not produce its rated power continuously, but somewhat less. The average power output, long term, can be deduced by taking capacity factors into account for both the hydro and wind power sources. Conservative values for these were taken as 0.25 for the wind, and 0.9 for the hydro. In practice, it is expected that the actual values for this are more like 0.35 and 0.99, for a reliable, well designed, maintained, and situated system. Taking such conservative values allows for a simpler estimation to be done, using simple probability to calculate the long-term output.

Table 3 Output Power Calculations

Power Source	Net Probability	Net Power	Net Power
Wind + Hydro	0.9×0.25	0.225×1040	234
Wind	0.1×0.25	0.025×380	9.5
Hydro	0.9×0.75	0.675×500	337.5
None	0.1×0.75	0.075×0	0
		Average Power	581 Watts

The average power output calculated in Table 3 translates to an annual generation capacity of over 5000 kWh. While less than the average usage, energy efficient houses and practices can allow a house to get by on this much power without sacrificing very much. Of course, if combined with a grid-tie system, this is hardly a problem because power can simply be imported from the national grid as required.

9 Conclusions

This work is an attempt to make renewable energy more reliable, cost effective, and accessible by exploring a different energy

combination system to that currently applied to wind and hydro power. Instead of the usual electrical combination of wind and hydro generators this work involved combining water and wind turbines mechanically, before driving an electrical generator. This new combination system is modeled and optimized in MATLAB, using a direct combination system commonly found in multi-engine helicopters. The system is found to operate satisfactorily. The research illustrates that there is potential for further research in the areas of pump-hydro storage and using a water pump as a turbine, both as an extension of this project. Research was undertaken regarding wind and water resource availability, and the turbines were chosen with these taken into consideration. Various combination systems were explored, including torque and speed split mechanical combinations, conventional electrical combination, and using a modified switched reluctance generator as a method of electro-mechanical combination. The system met the requirements in terms of resource constraints and power output. The new combination method was modeled in MATLAB, taking advantage of previous work done on Turgo modeling and the results obtained are highly encouraging to conduct the further research in the area.

10. Future Work

The system as implemented in the MATLAB model is more complex and costly than current, simple electrical combination systems, however further research and modeling will be undertaken in regards to using a pump-as-turbine, and incorporating pumped hydro energy storage into the simulation. Furthermore, CAD modeling and computer simulation will be carried out to further optimize the model parameters. A further development to make the system more accessible and reduce cost is the possibility of using a standard water pump in place of the turgo turbine.

Computer models for such implementations are few and far between, so finding or designing such a model would be of great contribution in the area.

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PORTABLE ENERGY UNIT FOR NATURAL DISASTER SITUATION

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Abstract

The portable renewable energy power unit was designed from a need. The need was for first response teams in remote natural disaster situations to have a reliable source of energy to power a small vaccine refrigerator or water purification system and a basic satellite communication system. It is important that such a need is explored as a practical solution has the potential to save the lives of people in remote areas, who would otherwise suffer from a lack of humanitarian aid. Currently diesel generators are the primary source of electricity generation for disaster responders and in most situations work very well and provide a sufficient amount of electricity to meet the power needs. However, in remote areas road infrastructure is often damaged. In this type of situation getting a constant supply of diesel to the area is an expensive or impractical operation. This is where the portable renewable energy power unit bridges the gap and allows a more practical solution to be implemented. The specific aim of the work was to design a compact, stand-alone, product that can be easily transported by people across uneven terrain. It can generate power from wind, solar and hydro energy sources. A complete Solid works model and FEA analysis, on required components, was completed. The scope of the work encompasses both the electrical and mechanical design of the system.

Keywords: *Renewable Energy, Portable Unit, Remote Application*

1. Introduction

Energy storage and power generation are some of the largest influences that have driven both the industrial and agricultural sectors in the developed world to what it is today [1]. In addition, a large majority of the world today is powered by finite, unsustainable resources such as fossil fuels [2]. With growing economies and growing populations of people, renewable energy generation, such as solar, wind, and hydro generation is quickly growing as a means of producing electricity for people. Natural Disasters, such as tsunamis, earthquakes and cyclones etc. are uncontrollable events that affect people's lives with little or no warning. Such events can wipe out homes and destroy power infrastructure, potentially leaving large amounts of people without power, water and sanitary items [3]. Over 50% of New Zealand's aid for natural disasters goes to the Pacific area. This includes island nations such as the Cook Islands, Fiji, Niue, Samoa, Solomon Islands, Tokelau, Tonga, Vanuatu and

others [4]. The pacific region is one of the most prone regions in the world for natural disasters to occur. 3.4 million people in the pacific islands have been directly affected by natural disasters and there has been 1700 reported deaths since 1950 (excluding Papua New Guinea) [5]. Furthermore, New Zealand is within this prone pacific region and experiences natural disasters, which creates demand in cities, towns and remote communities for disaster relief. There are about 100 formal disaster relief organizations worldwide. When a disaster strikes an area, 95% of the work that these organizations do is to address critical needs such as water, food and medical attention. Once these needs are addressed, shelter is the next priority [3]. In order to meet these initial needs for people, in areas that have lost power, having access to a reliable power resource is essential to provide the aid that is needed [6]. Transporting a power generator into a disaster zone has its issues, as often there is restricted access as road infrastructure can be damaged. Moreover, diesel power generators have the continued

issue of the transport of diesel into the area; they are also very heavy, make a lot of noise and contribute negatively to preventing greenhouse gas emissions into the atmosphere. Analyzing the trends, this presents a need for a mobile power generation unit, powered by abundant renewable resources such as solar, wind and hydro in order to provide reliable power to aid disaster relief applications. A disadvantage of an individual renewable energy source in the form of solar radiation or wind is its unreliability. There is not always direct sunshine and likewise, there is not always wind. Also, certain areas are not within close proximity of a flowing river. Furthermore, different environments provide different weather patterns. However, integrating renewable energy sources effectively into one system ensures the reliability of being able to produce power [6]. In addition, energy storage, such as batteries, will enhance the adaptability and reliability of a renewable energy system by being able to cover the fluctuations in the load of the applications being used [7]. As lowering greenhouse gas emissions is a sub-focus for mobile, off-grid, green power systems, it is important that the greenhouse emissions and sustainability of the energy storage systems are considered also as they could be in place for long periods of time [5],[7].

There are few mobile, hybrid renewable energy systems for disaster relief on the market. Most of the systems currently on the market are singular systems usually consisting of solar generation and the hybrid systems that do exist have very inefficient methods of optimizing wind power capture. Adding energy generation sources has the potential to improve reliability of producing power in any environment. Furthermore, current systems usually need to be towed on a trailer. This makes it difficult to access areas where road infrastructure is damaged and makes it difficult for such systems because of size

and weight to be transported into remote areas by air.

2. Current System

From literature review, it was found that there are two different types of hybrid systems in terms of the choice of energy generation that is currently being developed. The first system is wind/solar hybrid systems and the second is wind/solar and diesel hybrid systems. The wind, solar, diesel generation hybrids still have the issue of needing access to diesel supply and still emit greenhouse gasses, however, these issues are reduced due to the backup of the solar and wind resources. A third concept that arose within the literature was described as “an ad-hoc self-organized micro-grid based on moveable and renewable energy sources and fully distributed co-ordination between intelligent power routing nodes” [7]. The purpose of this concept is for remote communities and natural disaster victims to be able to rapidly establish a small grid of electricity sharing with little infrastructural development. There is need of further research to be done in this area as no working prototype of the proposed system was discovered.

A wind, solar hybrid trailer system called Mobile Elemental Power Plant (MEPP), designed for disaster relief in remote areas is presented [8] and shown in Figure 1.



Figure 1 CAD model of the MEPP

This system consists of two 240 watt solar panels and a 600 watt wind turbine that is fixed to a telescoping mast system that can raise the turbine to a height of 10 meters to gain access of less turbulent, faster flowing air [9]. The whole system is mounted on a trailer for mobility of the system with a vehicle. One issue with having the mobility of the system constrained to a vehicle is that if road infrastructure was destroyed by a disaster it would be difficult to get the system into the area of need. However, more research needs to be done to integrate micro-hydro generation into the system to increase the power reliability and flexibility. Furthermore, a smaller, more mobile version of the MEPP is required to increase system agility and reduce the cost.

3. Energy Storage Technologies

One issue related to renewable energy is its variability in its supply of electricity generation. Batteries can be integrated into a system to generate a more constant supply of power to users [4]. Chemical, kinetic or potential energy are all forms in which the electricity produced by the renewable resources can be stored in. The following is a list of storage appliances that can be used to store electricity [9].

- Batteries
- Flow batteries
- Fuel cells
- Fly wheels
- Superconducting magnetic energy storage (SMES)
- Super capacitors
- Compressed air energy storage
- Pumped hydro

Compressed air energy storage and pumped hydro are not sufficient for a movable micro-generation due to their size and weight. They are also very costly, therefore more appropriate for large scale energy systems. Super capacitors and SMES have high-power characteristics and their efficiencies are very good compared to other energy storage systems. They can also be drained and recharge numerous times without the capacity of energy storage

being lost [10]. SMES and super capacitors are still being developed before they become readily available to purchase on the market at a viable price, therefore they are not reviewed further in this article. According to [4], flywheels, fuel cells and flow batteries are seen to be more suitable for small renewable energy systems. Flywheel energy storage has high-power and short-cycle characteristics. Energy is lost through friction in the system. Hydrogen/fuel cell technology is environmentally friendly as it uses air and hydrogen to store electricity however, it is not readily available at a viable price to be used for further research. Flow batteries have high-power, low self-discharge but low efficiency characteristics[4].

4. Renewable Energy System Design

In this work a modular renewable energy system is presented as a solution to fulfill energy needs in a remote area struck by natural disaster. In this system wind turbine, hydro turbine, solar panels and power storage unit are housed in their own separate units. This arrangement provides several benefits to the first response team going into remote areas

- A modular setup provides maximum adaptability when packing the system into confined spaces, such as a helicopter or truck, as it can be configured in many different ways to fit in with other supplies and resources.
- The modular design makes human transportation of the system easier as the weight of carrying each wheeled unit can be split between each team member. If the system was integrated as one large unit, the logistics of carrying the unit becomes a lot more difficult as multiple people would have to handle the unit at one time.
- The product is also a lot more adaptable as a modular system in terms of the weather conditions for each circumstance. It is not always necessary that all modules are taken where aid is needed. For example if the weather forecast for an

affected remote area predicts a lot of sunshine but little wind and the area is not near a stream or river then it is practical to take only the solar and power storage unit as a power generating resource. In contrast, if the weather predicts rain, with little wind, but the affected area is near a constant flowing stream or river then it may be practical to just take the hydro and power storage unit. As demonstrated this provides a large amount of system adaptability and ensures no unnecessary weight and space is added to the aid supplies.

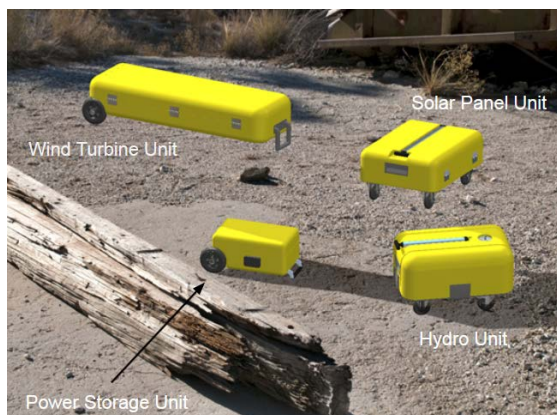


Figure 2. Solid works model for wind turbine unit, solar module unit, hydro turbine unit and storage unit.

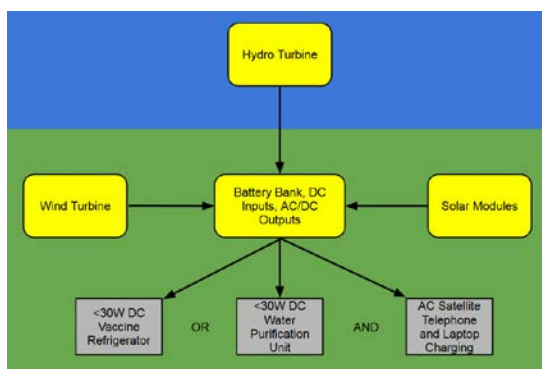


Figure 3 Flow diagram of the interaction of each module and the supply direction of electricity from each power source, to the selected appliances

5. Storage Unit

The storage unit is designed to supply electricity to first responders to power their vital equipment. Furthermore, the unit provides power redundancy when

electricity cannot be produced from the renewable power sources. The power generation sources run 12V DC into the power unit through sockets in the side of the unit. The inputs then run into an Ampair 300W regulator which regulates the current into the battery. There are two regulators as each regulator can only handle a maximum of two inputs. The battery is a 13.2V, 100Ah Lithium Ion Phosphate deep cycle battery, to provide up to 3 hours of redundancy for the system each day. From the battery there are two outputs, one AC and one DC. The AC output runs through a 200W pure sine wave inverter and the DC output runs directly to a DC socket. In addition a 6W cooling fan can be turned on, to cool the battery when necessary and all of the external components have rubber caps to seal them off from water or dust.

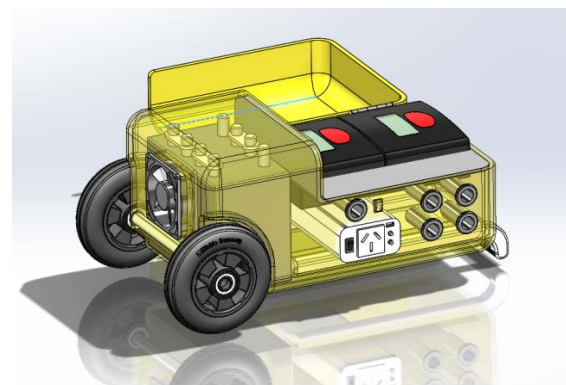


Figure 4 Storage unit design.

6. Solar Module

The solar array module is designed to capture the solar energy using photovoltaics and convert that energy into electricity, to be sent to the power storage unit. Three 55W solar panels as shown in Figure 5, are connected in parallel to create a 12V, 165W solar array. A retractable 12-gauge cable that extends up to 6 meters enables the connection between the solar array and the power storage unit. The unit also has the capability to connect with an additional module to increase the power output in an area that receives a small amount of day light hours. An added solar array connects in parallel with the existing array in order to keep the 12V output to the power storage

unit. The solar arrays angle can be adjusted in order to face perpendicular to the sun at all times of the day, ultimately increasing the arrays power output capacity. The panels fold away into a tough high density polyethylene case which protects the panels during transportation, storage and adverse weather conditions. The soft rubber caster wheels and retractable handle allow ease of human transportation across rough surfaces such as gravel, grass or dirt roads. Monocrystalline, Polycrystalline and thin film solar panels were considered for the solar array module. The most important factor for choosing the type of solar panel to use was the energy efficiency, as this system requires a high power output from a small, lightweight unit. While slightly more expensive, monocrystalline solar panels have the highest efficiency rates and were therefore chosen to be used on this design [9].



Figure 5 Front side of the solar array module, three 55W solar panels connected in parallel

7. Wind Turbine Model

The wind module is designed to convert wind energy into electrical energy using a 300W horizontal axis Ampair wind turbine. The turbine is elevated into the air, to a maximum of 6 meters in order to get into faster, more laminar flowing air. The 12m long 12 gauge power cord runs from the wind turbine, down the inside of the telescopic tube and out the bottom of the mast holder. The cord has an excess of 6 meters to run to the power storage unit. While the turbine system is a large structure when set up, it can be packed up into a compact casing for transportation and storage. The handle and soft rubber wheels

allow the case to be transported easily by a person across semi-rough terrain. Working and transportation setup of turbine is shown in Figure 6 and figure 7 respectively.



Figure 6 left) turbine out of its case before elevation. Right) wind turbine at its maximum 6m elevation.



Figure 7 Wind turbine disassembled and packed into its case.

The wind turbine module went through a range of design changes before arriving at the final design. Initially, like the other module designs, the stand for the turbine mast was integrated into the case. In this instance it was more practical to have the mast and stand separate from the case, due to the cases shape and size. A range of stand variations were investigated in the concept development stage, the final design was chosen due to its simplicity in the number of parts it uses which helps with reducing the weight of the product.

In order to have the turbine reach a setup height of 6 meters the mast material needs to be stiff, strong and lightweight. The two options that were considered for the mast material were aluminum and carbon fiber. As the wind turbine is supported near the top of the mast by guy wires the mast only

needs to support a downward force of 1000N (wind turbine), therefore, it can be assumed the strength of both the aluminum and carbon fiber (using 2mm wall thickness) tube is of sufficient strength to support the wind turbine. Although slightly more expensive the carbon fiber tubing is 25% lighter than the aluminum and also has a greater stiffness and strength. Therefore carbon fiber tubing was chosen for the product and the weight benefits outweigh the slight increase in price from extruded aluminum.

8. Hydro Turbine Unit

The hydro turbine is designed to be placed into a stream or river and convert the energy from the moving water into electricity from the use of a turbine. As shown in Figure 8 the hydro turbine is housed inside the plastic casing in its transport state, with the soft rubber caster wheels on the underside of the unit allowing the module to be pulled across semi rough terrain by its retractable pull handle. When the module is setup for electricity generation, the heavy duty latches are undone and the base of the module is flipped 180 degrees. The hydro turbine is then on the outside of the module and the wheels are housed inside the watertight unit. The unit is used as buoyancy for the hydro turbine when it is put into a river or stream, in order to prevent the turbine hitting the riverbed. A 4-meter carbon fiber telescopic pole used to hold the module out from the riverbank. The pole is held perpendicular to the water flow in tension by a spectra line. Both the pole and the guy line are fixed by 400mm stainless steel pegs and also have the option to be tied to a fixed object when pegging is not practical. The carbon fiber pole is also housed within the casing when the unit is in its transport state. The 10-meter-long 12-gauge power cord runs from the turbine, into the tube and out through the peg. The cord then has an excess of 6 meters to run into the power storage unit. Figure 9 shows hydro turbine setup in generation mode.

Whereas Figure 9 shows the placement of hydro turbine in flowing water.

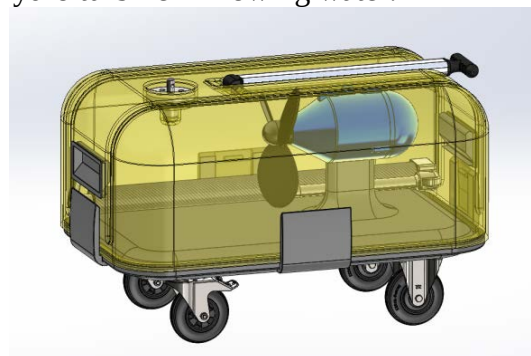


Figure 8 Hydro turbine unit in its transportation setup.

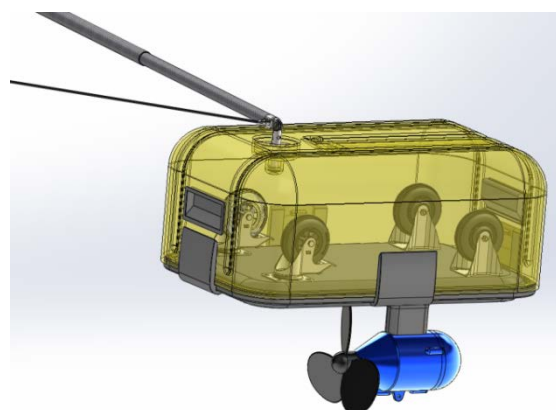


Figure 9 Hydro turbine setup for electricity generation



Figure 10 Function of the hydro turbine in a flowing river

9. Conclusions

The portable power generation system is a practical design that fulfils the need for first response teams in remote natural disaster areas, to have a reliable source of energy, to power a small vaccine refrigerator or water purification system and a basic satellite communication system. The system design

uses innovative features and materials in order to achieve a product that meets the design specifications of the application.

The system fills a niche in the market for a self-sustaining power unit that can be successfully transported by foot or by air into affected remote disaster locations. Because the system is the only product of its kind, there is a reasonable opportunity for the adoption, by non-profit aid organizations who are involved in disaster relief, as natural disasters are always going to exist and are increasing with global warming. With the increase in renewable energy technologies, the long term success of such a product is promising.

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FREQUENCY DEVIATION IMPROVEMENT OF A HYBRID MICRO-GRID SYSTEM CONTAINING WIND TURBINE AND CONTROLLABLE LOAD USING FRACTIONAL ORDER PID

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Abstract

The main goal which has been followed in this paper is to design an optimal fractional order PID (FOPID) controller that can sufficiently stabilize frequency in an isolated wind-diesel power system containing controllable load. In order to optimize parameters of the FOPID controller, an optimization problem has been implemented and solved using Jaya algorithm (JA). So, for proving the performance of applied method for damping frequency deviation in the wind-diesel system containing controllable load, the obtained results have been also compared to PID controller. The robustness of the proposed controller has been evaluated via ITAE and sensitivity analysis, which provides reasonable solutions.

Keywords: Wind-Diesel System, Jaya Algorithm (JA), FOPID Controller.

1. Introduction

One of the most demanding forms of energy, especially nowadays, is electricity which plays an important role in our daily life. Still, there are people that have not access to the grid or they are placed in either isolated or remote communities, where grid connectivity is not possible or even makes the environmental problems. For this category of people, electricity is supplied mainly by small diesel-based power generation that it has harmful effects on the environment, too [1]. So, renewable energy sources can be a good candidate for reducing the dependency of the power generation systems to the fuel and subsequently reduce the adverse effects of such systems on the environment. However, continuity of renewable energy sources is mostly unpredictable, so they may not supply desired power constantly. By combining renewable energy sources with non-renewable or storage devices, this problem can be easily addressed [2-5]. The fact that in a period of time, wind speed and load demand are not constant, bring an inequality between the power generation and load demand which subsequently

results in variation of the system frequency (f) and power (P) values.

Traditional controllers cannot ensure to control the system frequency in the presence of renewable energy sources [6] because it is not optimal for the whole set of operating conditions and configurations. Moreover, generating rate and capacity constraints in the load frequency control units are not easy to be considered in the controller design. Consequently, for an isolated Micro-Grid, it is necessary to have a robust controller over a wide range of system operating conditions [7]. The role of LFC is to maintain the power balance in the system such that the frequency deviation stays within a specified bound around its nominal value [6]. Because of taking minimum additional equipment, maintenance and etc. this control strategy may be highly cost saving and efficient.

As mentioned in the literature, different methods have been proposed by researchers in order to control the frequency instability in hybrid power system generations. Control of pitch and governor which is related to wind side and

diesel side, respectively, are main points which are involved in designation of the controllers. As mentioned before, there are many control strategies have been proposed in the literature. References [8-9] investigate optimization of the controller parameters. Also, in [10-11] PI controller, in [12-14] controller with variable structure and in [15-16] energy storage controller are mentioned. According to its simplicity in understanding the structure and its applicability for a large cluster of process which involve different dynamics, the proportional-integral-derivative (PID) controller has a widespread application and acceptance in the industrial process [17-18].

In contrast, new types of controllers may operate better in real-world, i.e. industrial applications. Thus, in this paper three FOPID controllers designed separately, one of them for diesel side, next one for pitch control of wind side and the last one is for controllable load (water-heater). It is shown that the appropriate selection of controller parameters results in satisfactory performance during system disturbances. So, for obtaining the favorable robustness, it's essential to optimize the FOPID gains. Also, optimal setting of FOPID controller gains is a multi-modal optimization problem (i.e., there is more than one local optimum) and more complex due to nonlinearity, complexity, and time-variability of the real world power system operations. Hence, local optimization techniques, which are well elaborated upon, are not suitable for such a problem. For this reason, in this paper, a simple and powerful optimization algorithm, called Jaya Algorithm (JA) is proposed for optimal tuning of the FOPID controller gains to stabilize system frequency response due to four different cases. JA has the ability to solve whether constrained or unconstrained optimization problems. The fundamental concept of the algorithm is that the solution obtained for a problem should move towards the best solution and

should avoid the worst solution. This does not need any algorithm-specific control parameters except common control parameters [19].

2. System Modeling

Figure 1 shows the configuration of the isolated hybrid wind-diesel power system.

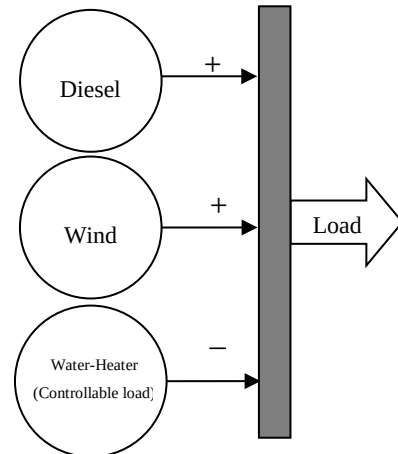


Figure 1. A simple scheme of the proposed micro-grid

Also, transfer function model of this system is shown in Figure 2 and its parameters are given in [11]. Various types of controllable loads are washing machines, air conditioners, water heating and vehicle-to-grid to name a few. Here, we have consider water-heater as a controllable load.

3. Proposed Controllers

Below are different controllers which have been used in this investigation are discussed.

3.1. PID

Below you can see the transfer function of the well-known PID controller.

$$U(s) = \left[k_p + \frac{K_i}{s} + K_d s \right] \Delta \omega(s) \quad (1)$$

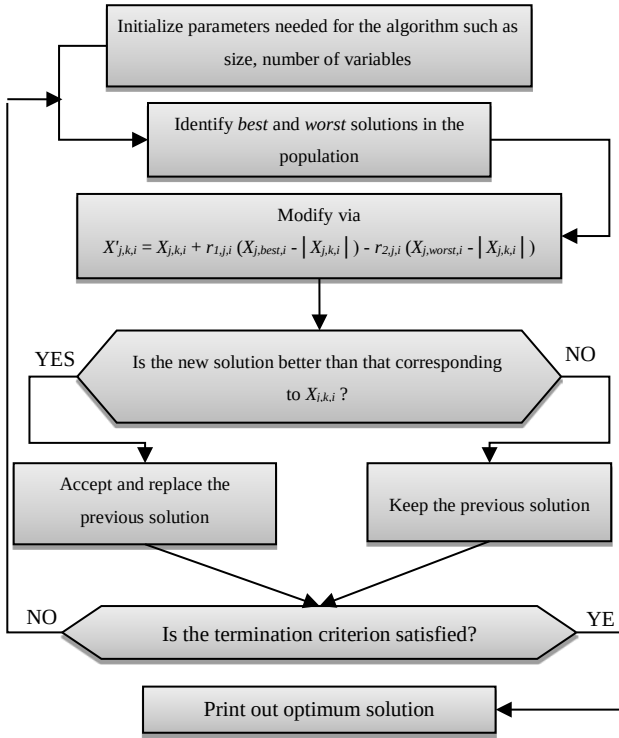


Figure 4. Flowchart of the proposed algorithm

If $X_{j,k,i}$ is the value of the j th variable for the k th candidate during the i th iteration, then the modification of its value will be done by Equation (1).

$$X'_{j,k,i} = X_{j,k,i} + r_{1,j,i} (X_{j,best,i} - |X_{j,k,i}|) - r_{2,j,i} (X_{j,worst,i} - |X_{j,k,i}|) \quad (4)$$

where, $X_{j,best,i}$ and $X_{j,worst,i}$ shows the value of the variable j for the best and worst candidate respectively. $X'_{j,k,i}$ is the updated value of $X_{j,k,i}$ while $r_{1,j,i}$ and $r_{2,j,i}$ are the two random numbers for the j th variable during the i th iteration in the range $[0, 1]$. The term “ $r_{1,j,i} (X_{j,best,i} - |X_{j,k,i}|)$ ” indicates the willing of the solution to move closer to the best solution and the term “ $-r_{2,j,i} (X_{j,worst,i} - |X_{j,k,i}|)$ ” indicates the willing of the solution to avoid the worst solution. $X'_{j,k,i}$ is accepted if it gives better function value. All the accepted function values at the end of iteration are maintained and these values become the input to the next iteration. The flowchart of the proposed algorithm can be seen in Figure 3. The main idea behind the name of Jaya algorithm is the fact that, the algorithm has the willing get closer to

success (i.e. obtaining the best solution) and tries to move away from failure (i.e. avoiding the worst solution). Reaching the best solution somehow considered as achieving victory and hence it is named as Jaya (a Sanskrit word meaning victory).research method section covers elaborations about the conceptual framework, research design, utilized method, analytic approaches and validation phases.

5. Problem Formulation

There are four kinds of performance criteria, generally considered in the control design, IAE, ITAE, ISE, and ITSE. However, ITAE and ISE criteria are mostly used in LFC studies for their better performance as compared to ISTE and IAE criterion. So, we just have selected ITAE for further investigations due to its quick setting feature.

$$J = \int_0^{t_s} t \times |\Delta F| dt \quad (5)$$

Where, t_s is total simulation time and ΔF is the variations in system frequency.

In the optimization process, it is tended to minimize J in order to damp frequency oscillations. The design problem can be formulated as the following constrained optimization problem, where the constraints are the limits of the gains of the controllers[21].

Minimize J Subject to:

$$\begin{aligned} 0 &\leq K_p, K_i, K_d \leq 15 \\ 0.5 &\leq \mu, \lambda \leq 1 \end{aligned} \quad (10)$$

Results of the controller parameters based on the objective function J , solved using the proposed Jaya algorithm, are given in Table 1. Figure 5 shows the minimum fitness functions evaluating process.

6. Analysis & Results

In order to expose the effectiveness of the proposed controller, the power system under study is faced to different disturbances based on wind speed and load

demand. There are four case of simulations are considered in this section.

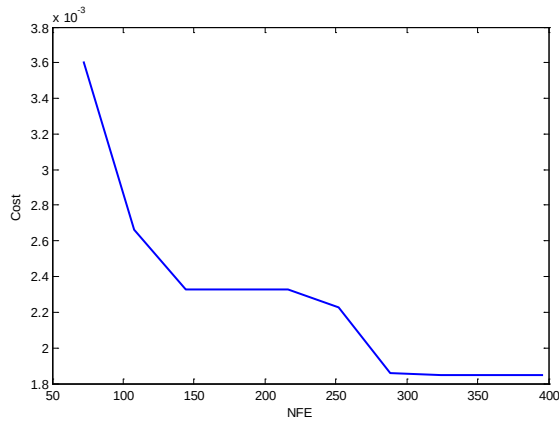


Figure 5. Fitness Convergence of FOPID using Jaya algorithm

Table 1. The optimum controller parameters obtained using jaya algorithm

Coefficient	FOPID			PID		
K_p	10.64	0	8.73	1.04	15	0.89
K_i	15	4.19	15	0	15	0.25
K_d	4.51	0	6.01	0.07	0.44	15
μ	0.5	0.94	0.94			
λ	0.82	0.66	0.87			

Case 1. Step change in both load demand and wind speed

In this case, it is assumed that in $t = 1$ sec, a step change ($\Delta P_L = 0.01$ pu, $\Delta P_{IW} = 0.01$ pu) occurred in both load demand and wind speed. Figure 6 shows the frequency response of the system with JA-FOPID and JA-PID.

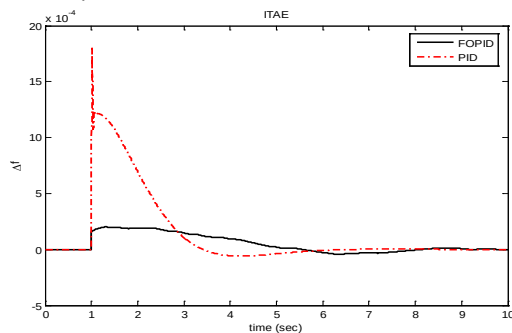


Figure 6. Frequency deviation against a step change in load and wind speed considering ITAE criterion

Case 2. Step change just in load demand

In this case of the simulations it's assumed that in $t = 1$ sec, a step change ($\Delta P_L = 0.01$ pu) occurred just in load demand. Figure 7

show the frequency response of the system with JA-FOPID and JA-PID controllers.

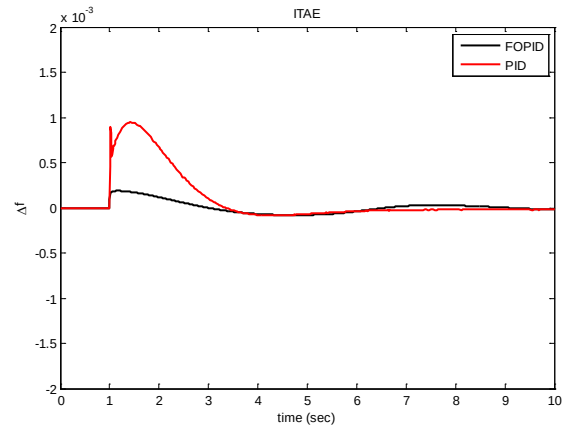


Figure 7. Frequency response for load change (ITAE)

Case 3. Step change just in wind speed

In this case, that in $t = 1$ sec, a step change ($\Delta P_{IW} = 0.01$ pu) occurred just in wind speed. Figure 8 shows that the control effect of the JA-FOPID controller on the system frequency deviation is superior to that of the JA-PID.

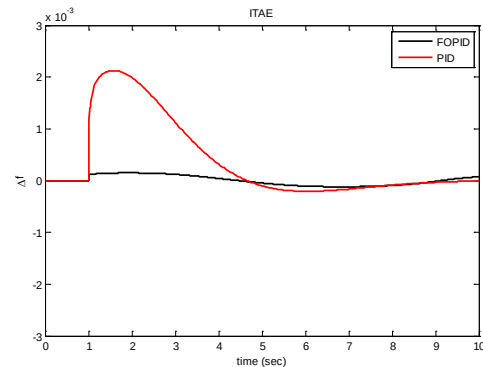


Figure 8. Frequency response for wind speed change (ITAE)

Case 4. Sensitivity analysis

In order to analyse the robustness of the controller, random load change (shown in figure 9) and random wind speed (shown in figure 10) are applied to the system.

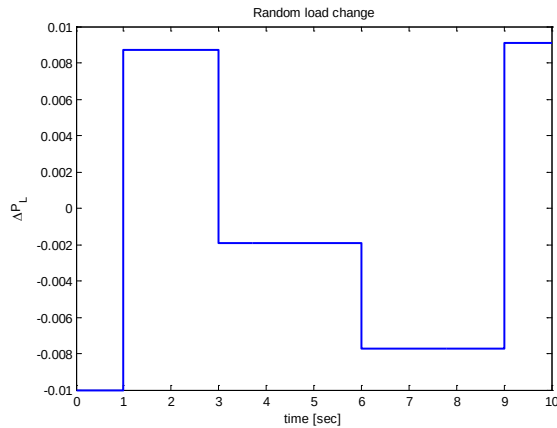


Figure 9. Random change in load demand

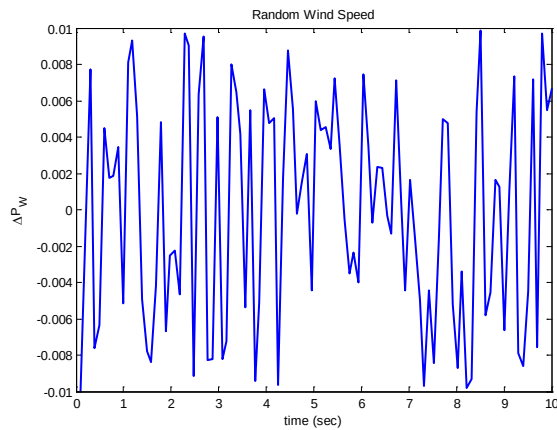


Figure 10. Random change in wind speed

Considering the obtained results, presented in figures 11 and 12, it's obviously clear, that the proposed method works well and proves the simulation results obtained in the previous cases.

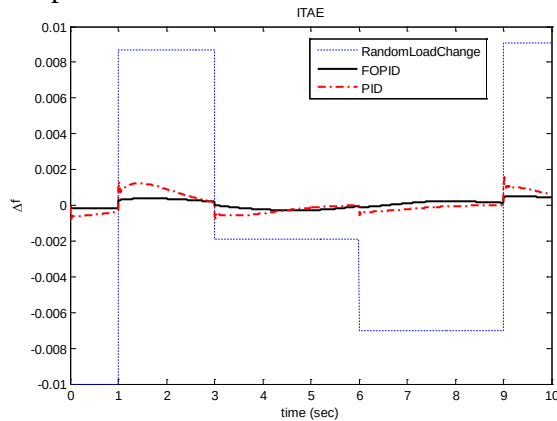


Figure 11. System frequency response under random change in load demand

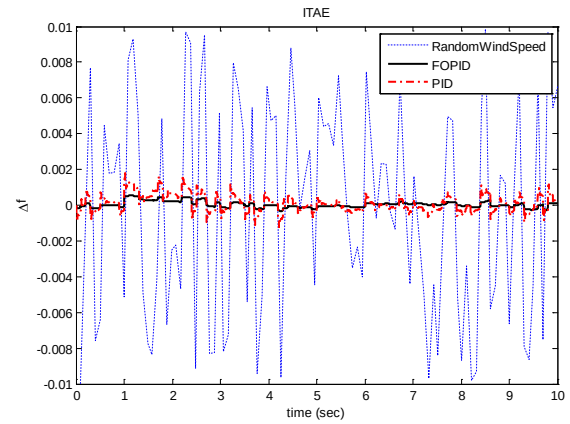


Figure 12. System frequency response under random change in wind speed

By a simple review of what we have shown in the above figures, its clearly obvious that are presented method can efficiently lower the frequency deviation for the applied micro-grid.

7. Discussion & Conclusion

In this paper, optimal FOPID controller design for the frequency control of a wind-diesel hybrid system containing controllable load is formulated as an optimization problem and solved using Jaya Algorithm (JA). The results of the proposed controller are compared with PID controller. In order to prove the performance of proposed method, simulations carried out in four cases. First step change in both load demand and wind speed. Then a step change just in load demand. Next, a step change just in wind speed. And finally, we considered a random change in the wind speed and a random change in the load demand, regarding sensitivity analysis of the system. Simulation results show that the JA-based FOPID controller (JA-FOPID) has better performance compared with JA-based PID (JA-PID) controller from the perspective of the response to change (whether step or random change) in load demand and wind speed. Also, ITAE performance index defined for JA-FOPID and JA-PID controllers, which proves that the proposed JA-FOPID controller is very effective and robust compared to JA-PID.

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TREATMENT OF TEXTILE WASTE WATER BY ADSORPTION USING GRANULAR ACTIVATED CARBON ALONG WITH ISOTHERM MODELING AND KINETICS

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Abstract

Textile industries are one of the major polluters in recent times. These industries produce huge amount of waste water which are highly in need of proper treatment. The project focuses on the treatment of textile waste and dyes with Granular Activated Carbon (GAC) by adsorption process. After treatment with 4g GAC/L wastewater, the Chemical Oxygen Demand (COD) of sample waste water reduced almost 65%. A huge change was also found in the physical appearance of the sample water. After treatment almost 86% color was gone. The pH also increased by about 5%. Four isotherm models-Linear, Langmuir, Freundlich and Temkin were studied. Linear isotherm showed the best fitting with the equilibrium data in terms of the coefficient of determination (R^2). In the kinetics study, pseudo first-order, pseudo second-order, Elovich's equation and intra particle diffusion kinetic models were studied. Elovich's equation well fit the experimental data.

Keywords: Adsorption-isotherm, Adsorption-kinetics, Granular activated carbon, Textile wastewater, Dyestuffs.

1. Introduction

Granular activated carbon is used for the treatment of industrial waste water and many other water supplies. It provides a versatile technology suitable for removing a broad range of both organic and inorganic pollutants. These pollutants are generally of concern because of their toxicity to human health and existence of aquatic animals. [1] Some contaminants have a special risk due to their high frequency of occurrence in surface waters, among which non-biodegradable organic compounds (COD), adsorbable organic halogens (AOX), toxicity, color compounds and dyestuffs, inhibitory compounds for biological treatment systems, aromatic compound including phenol and bis-phenol A (BPA), chlorinated or halogenated organic compounds and pesticides are common. [4] Today we have our modern and civilized world. But to get to this point, the things that have grown along with population are the industries. Textile industries are second largest industries globally. According to a

report of World Bank, almost 20% of global industrial water pollution comes from the treatment and dyeing of textiles [2]. As an economically growing country, the textile industries are spreading its wings in Bangladesh as well. Almost 80% of national exports in Bangladesh are based on Textile Mills. So it is one of the most important industries in Bangladesh. But every blessing has a dark side and so does these industries. The problem is that these textile industries produce waste water which causes environmental problems, mostly pollution of water resources of the country. The effluent waste water contains not only dissolved dye, but also poisonous metallic ions, aromatic amines, ammonia, alkaline salts and large amount of pigments. Some of these chemicals cannot be filtered or removed. These particles, if comes in contact with living beings may cause fatal diseases and destruction of the natural system. So the treatment of the textile waste water is very important.

GAC is generally made from organic materials with high carbon contents such as wood, lignite and coal. The basic characteristic that differentiates GAC to PAC is its particle size. Typically, GAC has a diameter ranging between 1.2 to 1.6 mm and an apparent density ranging between 400.462 and 496.572 kg/m³, depending on the material used and manufacturing process. The bed density is about 10 percent less than the apparent density and is used to determine the amount of GAC required to fill a given size filter. The uniformity coefficient of GAC is quite large, typically about 1.9, to promote stratification after backwashing and minimize desorption and premature breakthrough that can result from mixing activated carbon particles with adsorbed compounds with activated carbon particles with smaller amounts of adsorbed compounds. Iodine and molasses numbers are typically used to characterize GAC. These numbers describe the quantity of small and large pore volumes in a sample of GAC. A minimum iodine number of 500 is specified for activated carbon by AWWA standards. [3]

Activated carbon is one of the most effective media for removing a wide range of contaminants from industrial and municipal waste waters, landfill leachate and contaminated groundwater. As the world's most powerful adsorbent, it can cope with a wide range of contaminants. Different contaminants may be present in the same discharge and carbon may be used to treat the total flow, or it may be better utilized to remove specific contaminants as part of a multistage approach.

Once granular activated carbon is saturated, or the treatment objective is reached, it can be recycled, by thermal reactivation for reuse. Reactivation involves treating the spent carbon in a high temperature reactivation furnace to over 800°C. During this treatment process, the undesirable organics on the carbon are thermally destroyed. Recycling activated carbon by thermal reactivation meets the

environmental need to minimize waste, reducing CO₂ emissions and limiting the use of the world's resources. [4]

The project is mainly on the treatment of textile waste and dyes with coconut shell based Granular Activated Carbon (GAC) by adsorption process. Erlen Meyer flasks were used for conducting the adsorption process in a 24 hour run in batch process. Different amounts of GAC, from 0.09g to 1.5g were put in a fixed volume of 150 ml of sample waste water. Then the solution was filtered and the filtrate was collected and corresponding tests were conducted. After figuring the optimum amount of GAC, a sample was made with that amount and collected at different times of 24 hour run to find out the kinetics and isotherms. In this experiment, it is mainly focused to remove the color compound of dyes, COD and total dissolved solids. With further study and modification on this project it could be very effective in the treatment of textile wastes and to prevent the environmental pollution in Bangladesh and also the whole world.

2. Literature Review.

The process by which liquid or gaseous molecules are concentrated on a solid surface can be referred to as adsorption. In this case the solid surface is activated carbon. This is different from absorption process, where molecules are taken up by a liquid or gas. [4]

Activated carbon is commonly used to adsorb natural organic compounds, taste and odor compounds, and synthetic organic chemicals in water treatment. Adsorption is both the physical and chemical process of accumulating a substance at the interface between liquid and solids phases. Activated carbon is an effective adsorbent because it is a highly porous material and provides a large surface area to which contaminants may adsorb. The two main types of activated carbon used in water treatment applications are granular activated carbon (GAC) and powdered activated carbon (PAC).

However, commercially available activated carbon is expensive. In the last years, special emphasis on the preparation of activated carbons from several agricultural by-products has been given due to the growing interest in low cost activated carbons from renewable, copious, especially for application concerning treatment of wastewater. Researchers have studied the production of activated carbon from palm-tree cobs, plum kernels, cassava peel, bagasse, jute fiber, rice husks, olive stones, date pits, fruit stones and nutshells. The advantage of using agricultural by-products as raw materials for manufacturing activated carbon is that these raw materials are renewable and potentially less expensive to manufacture. [10]

The two most common options for locating a GAC treatment unit in water treatment plants are: (1) post-filtration adsorption, where the GAC unit is located after the conventional filtration process (post-filter contactors or adsorbers); and (2) filtration-adsorption, in which some or all of the filter media in a granular media filter is replaced with GAC. In post-filtration applications, the GAC contactor receives the highest quality water and, thus, has as its only objective the removal of dissolved organic compounds. Backwashing of these adsorbers is usually unnecessary, unless excessive biological growth occurs. This option provides the most flexibility for handling GAC and for designing specific adsorption conditions by providing longer contact times than filter-adsorbers.

In addition to dissolved organics removal, the filter-adsorber configuration uses the GAC for turbidity and solids removal, and biological stabilization. Existing rapid sand filters can frequently be retrofitted for filtration-adsorption by replacing all or a portion of the granular media with GAC. Retrofitting existing high rate granular media filters can significantly reduce capital costs since no additional filter boxes, underdrains and backwashing systems may be required. However, filter-adsorbers have

shorter filter run times and must be backwashed more frequently than post-filter adsorbers (filter-adsorber units are backwashed about as frequently as conventional high rate granular filters). In addition, filter-adsorbers may incur greater carbon losses because of increased backwashing and may cost more to operate because carbon usage is less effective.

Primary factors in determining the required GAC contactor volume are the (1) breakthrough, (2) empty bed contact time (EBCT), and (3) design flow rate. The breakthrough time is the time when the concentration of a contaminant in the effluent of the GAC unit exceeds the treatment requirement. As a rule of thumb, if the GAC effluent concentration is greater than the performance standard for over three consecutive days, the GAC is exhausted and must be replaced/regenerated. The EBCT is calculated as the empty bed volume divided by the flow rate through the carbon. Longer EBCTs can be achieved by increasing the bed volume or reducing the flow rate through the filter. The EBCT and the design flow rate define the amount of carbon to be contained in the adsorption units. A longer EBCT can delay breakthrough and reduce the GAC replacement/regeneration frequency. The carbon depth and adsorber volume can be determined once the optimum EBCT is established. Typical EBCTs for water treatment applications range between 5 to 25 minutes.

The carbon usage rate (CUR) determines the rate at which carbon will be exhausted and how often carbon must be replaced/regenerated. Carbon treatment effectiveness improves with increasing contact times. Deeper beds will increase the percentage of carbon that is exhausted at breakthrough. The optimum bed depth and volume are typically selected after carefully evaluating capital and operating costs associated with reactivation frequency and contactor construction costs.

Depending on the economics, facilities may have on-site or off-site regeneration systems or may waste spent carbon and replace it with new. Spent GAC must be disposed of recognizing that contaminants can be desorbed, which can potentially result in leaching of contaminants from the spent GAC when exposed to percolating water, contaminating soils or groundwater. Due to contamination concerns, spent GAC regeneration is typically favored over disposal. The three most common GAC regeneration methods are steam, thermal and chemical; of which thermal regeneration is the most common method used. Available thermal regeneration technologies used to remove adsorbed organics from activated carbon include: (1) electric infrared ovens, (2) fluidized bed furnaces, (3) multiple hearth furnaces, and (4) rotary kilns. [3]

3. Research Methods

3.1 Materials

The adsorbent was coconut shell based granular activated carbon which is used commercially. The activated carbon crystals were of 8x16 mesh number, pH value 7, specific surface area 1060 m²/g, hardness 95% and 0.51 g/cm³ bulk density. Textile dyeing wastewater was collected from a local industry in Gazipur, Dhaka, Bangladesh.

3.2 Experimental

Equilibrium adsorption isotherm study was carried out using bench top shaker. To run the experiment in a batch operation, different amounts of GAC weighing 0.09 g to 1.5 g were measured using a digital electronic weighing machine. These measured amounts of GAC were then placed into 250 ml Erlen Meyer flasks. Sample wastewater was added into each flask and the volume was made 150 ml. Then the flasks were covered with aluminum foil paper to prevent contamination. The flasks were then put onto a shaker for 24 hours. A blank experiment (without addition of GAC) was

also carried out to measure the degradation of organics without GAC. The experiment was carried out at constant speed of 250 rpm. After the experiment, the samples with GAC were filtered using a vacuum filtration unit. Whatman® 42 quantitative filter paper (diameter 9.0 cm, 2.5 µm pore, Sigma Aldrich) was used to filter the treated wastewater for removing the GAC crystals. The filtrate was collected to measure COD, color and other the physical and chemical properties.

COD was measured according to standard methods (American Public Health Association, 2005). To measure the COD, 4 ml of COD reagents and 3 ml of dilute Sulfuric Acid solutions were added to a 2 mL sample. These samples were placed onto a HACH DRB 200 COD reactor and digested at 150° C for 2 hours. The COD vials were taken out from the reactor and cooled to room temperature. The absorbance was measured by a HACH Spectrophotometer (DR 3900 Benchtop VIS Spectrophotometer with RFID Technology). The color of raw and treated wastewater was measured using standard methods (APHA 2005).

3.3 Adsorption Isotherms

Equilibrium study on adsorption provides information on the capacity of the adsorbent. An adsorption isotherm is characterized by certain constant values, which express the surface properties and affinity of the adsorbent and can also be used to compare the adsorptive capacities of the adsorbent for different pollutants. The experimental data were fitted using different equilibrium models (Linear, Langmuir, Freundlich and Temkin) and kinetic models (pseudo first-order, pseudo second order, Elovich's equation and intra-Particle diffusion kinetic models). The amount of organics adsorbed per unit adsorbent mass was calculated as follows [5]:

$$q_e = \frac{(C_i - C_e)V}{m}$$

Where, C_i is the initial concentration of COD in wastewater, mg/L; C_e is the equilibrium concentration of COD in wastewater after treatment, mg/L; V is the volume of wastewater, L; and m is the mass of GAC used, g. The removal efficiency of organics can be calculated from the equation below:

$$\% \text{ removal} = \frac{(C_i - C_e) * 100}{C_i}$$

3.3.1 Freundlich isotherm

The Freundlich adsorption isotherm assumes that adsorption occurs on a heterogeneous surface through a multilayer adsorption mechanism and that the adsorbed amount increases with the concentration according to the following equation [6]:

$$q_e = K_f C_e^{1/n}$$

Where q_e is the amount adsorbed at equilibrium in terms of (mg organics adsorbed/g PAC), C_e is the equilibrium COD concentration, K_f (L/g) is the Freundlich constant and $(1/n)$ is related to the strength of adsorption driving force and the degree of nonlinearity between solution concentration and adsorption. The plot of $\ln q_e$ versus $\ln C_e$ is employed to generate K_f value from the intercept and n value from the slope. The linear form of Freundlich equation is:

$$\ln q_e = \frac{1}{n} \ln C_e + \ln K_f$$

3.3.2 Langmuir isotherm

The Langmuir model considers several assumptions: the adsorption is localized, all the active sites on the surface have similar energies, none interaction between adsorbed molecules exists, and the limiting reaction step is the surface reaction as in the heterogeneous catalytic reaction. The Langmuir equation can be written as [6]:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e}$$

where C_e and q_e have the same meaning as in the Freundlich isotherm. q_m is the maximum uptake per unit mass of carbon (mg/g), and K_L is the Langmuir constant related to the adsorption energy (L/mg). The linear form of Langmuir equation is:

$$\frac{1}{q_e} = \frac{1}{q_m K_L C_e} + \frac{1}{q_e}$$

3.3.3 Temkin isotherm

Temkin and Pyzhev suggested that, because of the existence of adsorbate–adsorbate interactions, the heat of adsorption should decrease linearly with the surface coverage. The linear form of Temkin isotherm model is given by the equation [6]:

$$q_e = \frac{RT}{b} \ln K_T + \frac{RT}{b} \ln C_e$$

$$\text{Or, } q_e = B \ln A + B \ln C_e$$

Where, b is the Temkin constant related to the heat of sorption, J/mol and K_T is the Temkin isotherm constant, L/g, R is the universal gas constant, J/mol/K and T is the liquid temperature, K.

3.3.4 Linear Isotherm

The linear isotherm model can be expressed by the following equation:

$$q_e = k \cdot C_e$$

where q_e is amount of solute adsorbed per unit weight of solid at equilibrium in g/g or mg/g and C_e is the equilibrium concentration of solute remaining in the solution, when amount adsorbed equals q_e .

3.4 Adsorption Kinetics

3.4.1 Pseudo first-order model or Lagergren's equation

The pseudo first-order equation of Lagergren is one of the most widely used for the adsorption of solute from a liquid solution. The linear form can be written as [6]:

$$\ln(q_e - q_t) = \ln q_e - k_1 t$$

where k is the kinetic constant of pseudo first-order adsorption (h⁻¹), and q_e and q_t (mg/g AC) represent the amounts of adsorbed amount at equilibrium and at time t (h), respectively.

3.4.2 Pseudo second order

A pseudo second-order equation based on equilibrium adsorption can be expressed as [6]:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e}$$

where k_2 (g/mg h) is the rates constant of second-order adsorption. If second-order kinetics is applicable, the plot of t/q versus t should show a linear relationship.

3.4.3 Intra-particle diffusion model

The sorption kinetics may alternatively be described from a mechanistic point of view. The overall adsorption process may indeed be controlled either by one or more steps, e.g. film or external diffusion, pore diffusion, surface diffusion and adsorption on the pore surface, or a combination of more than one step. The possibility of intra-particle diffusion was explored by using the intra-particle diffusion model, according to which the amount adsorbed at time t , q_t , reads [6]:

$$q_t = k_{id} \cdot t^{1/2} + \Theta$$

Where, K_{id} is the intraparticle diffusion rate constant, mg/g; and Θ is the intercept, mg/g.

3.4.4 Elovich's equation

Elovich's equation describes activated adsorption. It was established through the work of Zeldowitsch dealing with the adsorption of carbon monoxide on manganese dioxide Elovich's equation has also been used for describing successfully the adsorption of pollutants from aqueous solutions in recent years and can be expressed as follows [6]:

$$q_t = \frac{1}{b} \ln(ab) + \frac{1}{b} \ln(t)$$

where a is the initial adsorption rate (mg/(g h)), and the parameter $1/b$ (mg/g) is related to the number of sites available for adsorption. If this equation applies, it should lead to a straight line by plotting q_t as a function of $\ln t$.

4. Analysis & Results

The wastewater was treated in a batch study using different GAC doses for the study of different isotherm models. However, for the

study of adsorption kinetics model, a separate batch study with optimum GAC dose (4g GAC/L wastewater) for the treatment of wastewater was selected and sampling was performed at different time interval.

4.1. Equilibrium Adsorption Performance

The concentrations of COD both raw and treated wastewater were measured and Figure 1 shows the removed concentration in mg/L with the GAC dose in g/L. The COD removal efficiencies enhanced with increasing in GAC dosage; whilst decreasing in the equilibrium adsorbed amount per g of GAC. For example, 0.6 g/L of GAC dosage removed 41% COD, which increased to 68% after addition of 4 g/L GAC dose. Further increase of GAC dose from 4 g/L to 10 g/L didn't increase any COD removal efficiencies considerably.

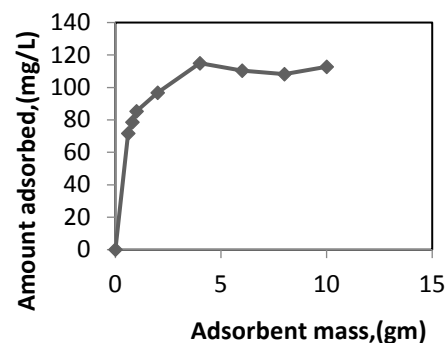


Fig 1: Equilibrium adsorption curve for determining the optimum dose of GAC

However, the amount of COD adsorbed on GAC increased from 60 mg/L for 0.5 g GAC/L wastewater to 120 mg/L for 4 g GAC/L wastewater as shown in the Figure 1. This could be explained that at higher GAC dosage, the ratio of the initial concentration of organic matters (COD) to the GAC available site is low and subsequently the fraction of sorption is independent of the initial concentration. Thus, a lower removal of COD per g of GAC (but higher COD removal efficiency) was observed. On the other hand, at the lower GAC dosage, the ratios of the initial concentration of organic matters (COD) to

the GAC available site is high and thus increase the adsorption capacity per g of GAC. The available adsorption sites became fewer compared to the amount of organic matters and hence resulted in the lower COD removal efficiency (Xing et al., 2008).

4.2 Isotherm evaluation and study

Description of adsorption equilibrium by an appropriate isotherm is the most important step to design an adsorption system as it reflects the capacity or affinity of an adsorbent for a particular adsorbate. Adsorption of COD by GAC from textile dyeing wastewater was

modeled using Linear, Freundlich, Langmuir and Temkin isotherms and Figure 3 shows those isotherms. The quality of the fit of isotherms was assessed using the correlation coefficient. All the parameters of the four different studied isotherms and the values of their corresponding correlation coefficients (R^2) for all isotherms from the isotherm plots are listed in Table 1. The q_m is attributable to the saturation amount of organic matters adsorbed in the Langmuir isotherm. Based on the results listed in Table 1, best isotherm models fitted for COD removal are determined in the order: Linear > Temkin > Freundlich > Langmuir.

Table 1: Parameters and correlation coefficients of Linear, Langmuir, Temkin and Freundlich Isotherms.

Linear		Langmuir			Freundlich			Temkin		
R^2	K (L/g)	K_L (L/mg)	q_m (mg/g)	R^2	n	K_f (mg/g)	R^2	K_t (L/mg)	B	R^2
0.951	2.45	0.0091	11.76	0.638	0.243	1.819	0.846	$e^{-4.08}$	196.3	0.933

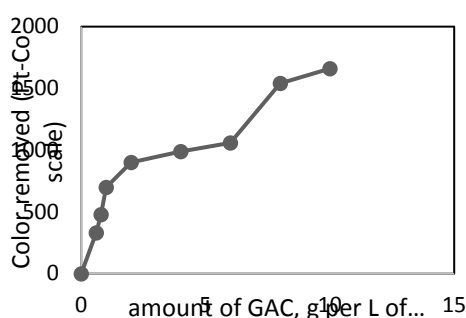


Figure 2: Removed Color on Pt-Co scale with different doses of GAC

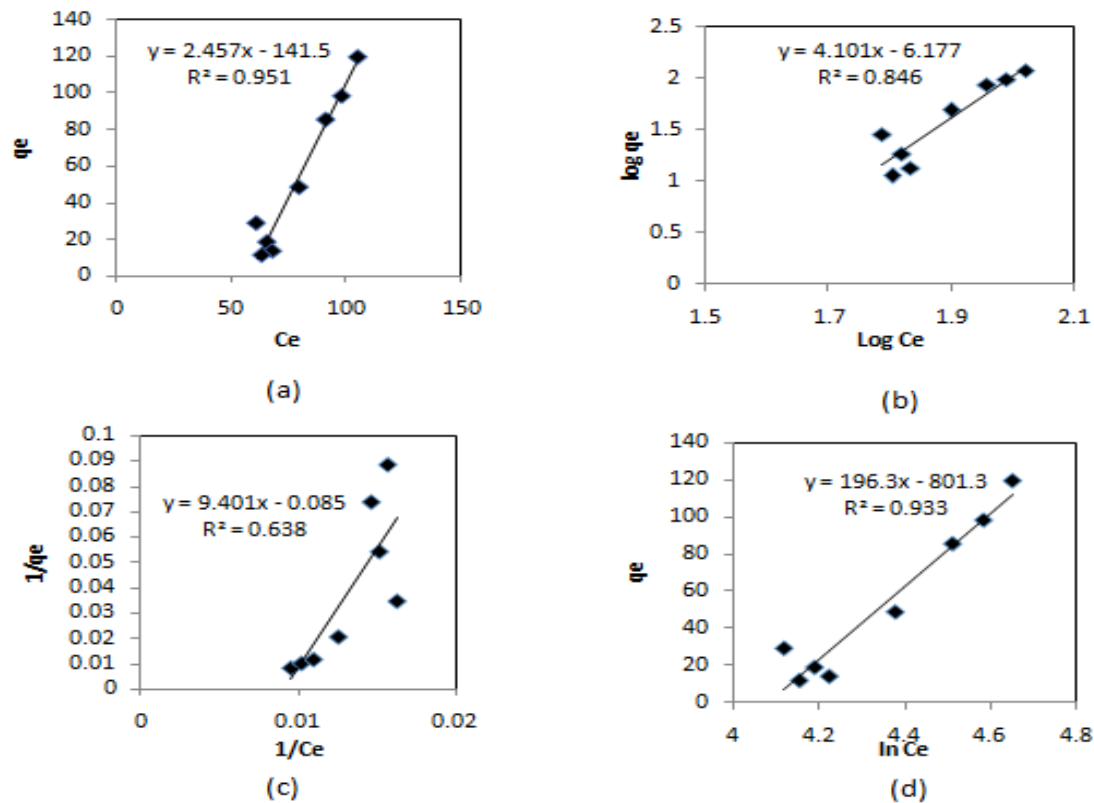


Figure 3: (a) Linear (b) Freundlich (c) Langmuir and (d) Temkin isotherms for adsorption Modeling study.

4.1. Kinetic study

As in the Figure 1, we observed that the 4 g GAC/L wastewater was optimum GAC dose for COD removal. Thus the 4 g/L GAC

dose was selected as optimum GAC dose for adsorption kinetics study.

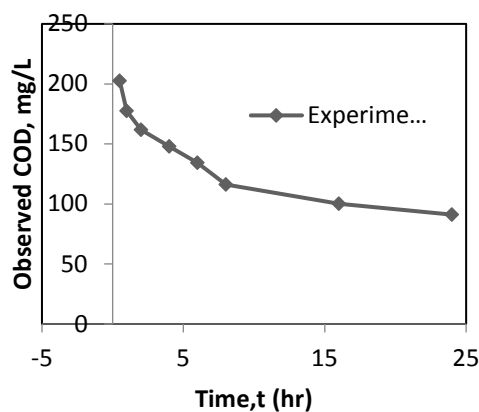


Figure 4: COD concentration change during experiment with time.

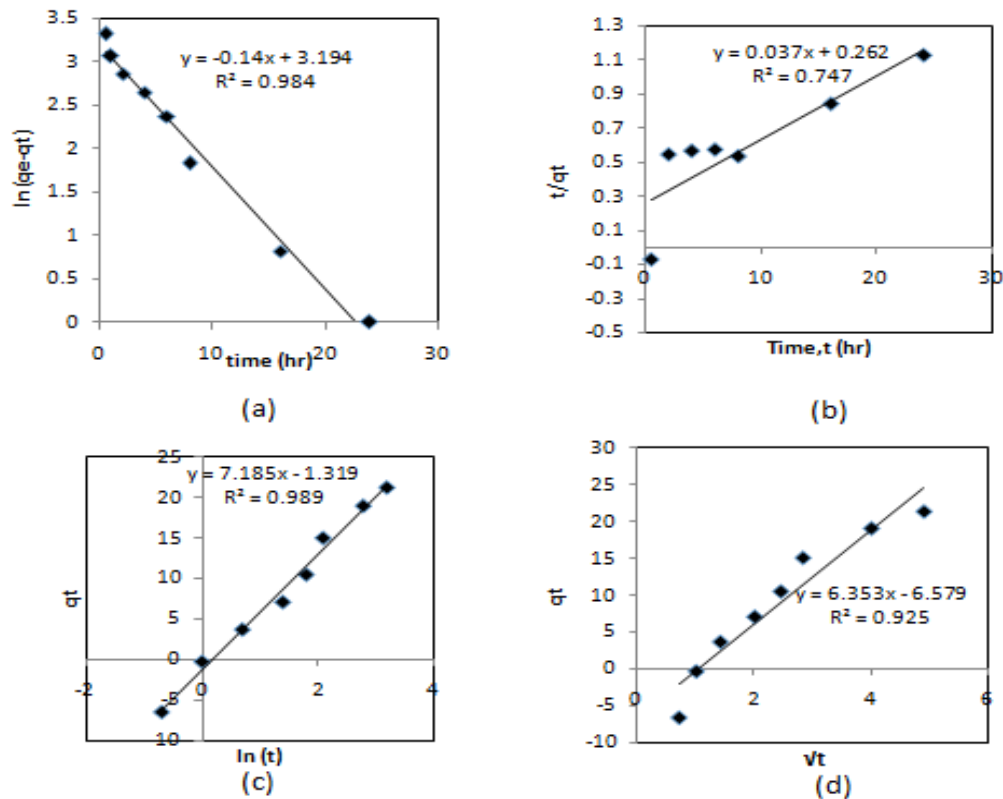


Figure 5: Application of the (a) Pseudo first-order (b) Pseudo second-order (c) Elovich's equation (d) Intra-Particle diffusion for the experimental data.

Figure 4 shows the graphical representation of adsorption characteristics of measured COD of the sample as a function of time. It was observed that initially the COD removal was fast and within 2 hrs COD reduced by almost 65%. Then the rate became slow because of less concentration gradient of COD between bulk liquid and onto the GAC surface and it reached equilibrium within 6 hrs. In order to analyze the adsorption kinetics, correlations between adsorbed amounts and time were sought for, through the testing of different

mathematical expressions corresponding to various models, namely: pseudo first-order, pseudo second-order reaction and then Intra-particle diffusion and Elovich's equation. Figure 5 represents these models. Table 2 represents the kinetic parameters from all the studied models. . From the Table it is observed that Elovich's equation fitted best with the experimental data as the R^2 value is 0.989 here. So the adsorption of GAC in dyeing textile wastewater follows Elovich's equation.

Table 2: Obtained kinetic parameter from the adsorption process

Pseudo first-order			Pseudo second-order			Elovich's equation			Intra-Particle diffusion		
k (h ⁻¹)	q _e (mg/g)	R ²	k' (g/(mg·h))	q _e (mg/g)	R ²	a (mg/(g·h))	1/b (mg/g)	R ²	K _{id} (mg/(g·h ^{1/2}))	Θ (mg/g)	R ²
0.140	24.38	0.984	0.005	27.02	0.747	0.167	7.194	0.989	6.353	6.579	0.925

5. Discussion & Conclusion

This study demonstrated that GAC is an excellent adsorbent for removal of waste and color from textile waste. Within 24 h, 4 g/L GAC could remove 78% of color. Adsorption behaviour is described by a Linear isotherm model among four adsorption isotherm equilibrium models - Linear, Freundlich, Temkin, and Langmuir. The classification of the kinetic models according to the simulation of the adsorption study is: Elovich's equation > Intra-particle-diffusion > Pseudo-first order > Pseudo-second order Kinetic model. So the experimental data follows Elovich's equation model which is actually a chemisorption process for the adsorption of GAC over time.

GAC is already used by water treatment plants on either a full time basis or as needed for taste and odor control or removal of organic chemicals. Application of GAC generates additional sludge which is not likely to be classified as a hazardous waste. However, the results from this experiment suggested that the GAC is a promising adsorbent for the removal of organics from textile dyeing wastewater. Thus, further study of GAC in combination with coagulation-flocculation and biological processes is necessary to achieve effective utilization of GAC in the wastewater treatment. This modification on

this project could be more effective in the treatment of textile wastes and to prevent the environmental pollution in Bangladesh.

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A BIG LOST FRAGMENT; EVALUATING SOCIO-CULTURAL CONSIDERATIONS IN MEHR HOUSING PROJECT CASE STUDY ANALYSIS OF MANZARIEH

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Abstract

While being at the population peak, the needs for mass affordable housing drove 9th Iran government toward commencing a national wide policy called Mehr Housing. The result of the accelerated project has exposed in various forms. It seems that the issues originate in ignoring socio-cultural trends of the users, especially cultural traditions and lifestyles. The paper presents findings from observations along with study of historical background of inhabitants of newly constructed units in Manzarieh ,the main compound occupied by Bakhtiary community in west of Iran.. In terms of behavioral and socio-cultural background classification, results suggest that socio-cultural factors related to spatial structures and it's accordance to people behavior are inadequately reflected in the location and design of the units and their public spaces as well. These findings have implications for future housing policies in the country.

Keywords: Shahrekord, Housing, socio-cultural, Manzarieh, Urban development

1. Introduction

Rising significance of housing owing to urban population growth, necessitating proportionate design approach. Due to young population peak of Iran on one hand and housing shortage for low income people on the other hand, 9th government has involved in another mass affordable housing project after various previously failed projects such as leased housing. Mehr housing project that of which a national wide policy trying to provide affordable housing for low-medium income people in suburbs wasn't accepted by most of the users as their own "home" despite extensive financial support by the government. Many of them left the dormitory like residential complexes immediately after earning money, immigrating to the main city, others still waiting for so. For those who have to stay, it's been a crucial to modify or transform the houses. While the most of similar Mehr housing projects around the country intend to shelter the people with variety of socio-cultural situation, this paper has explored Manzarieh as the case study with the users from rich socio-cultural background.

This paper focuses on socio-cultural incompatibility as the main factor of either immigrating or not being attached to the housing environments from urban design standpoint. The methods of observation along with a socio-cultural background study of the settlers in Manzarieh as one of the largest cases of Mehr housing projects, is carried out as a case study for the failed projects. The findings are expected to inform future policy making for housing in the country.

2. Literature Review

2.1 Affordable housing

According to statistical center of Iran, a housing unit is defined as a place, space or environment in which one or more households reside while it is connected to one or several entrances [1]. While the term reflects government attitude toward housing, it underestimates other impressive aspects. According to researchers, housing possesses hidden aspects in addition to economic and technical features [2]. Quoting from Bourdieu (1986) the so called "cultural capital" that has capacity to

transform to other capitals during the life can crucially associate with individual lives in housing [3]. Rapoport (1990) on the other hand defines housing as a place including concepts of identity, dignity of inhabitants, privacy and a behavioral environment. [4]

Possessing various names and forms in different countries, affordable housing is not of unanimous define due to different income level and approach toward housing in various areas in the world. Each country has its own criteria to determine a house as affordable while the United States as well as Australia are of the role models in evaluating affordable housing. Construction quality, community and cultural considerations however are of commonplace criteria in different countries.

It is argued here that creation of home place is as important to urban poor classes as to other more fortunate citizens. There are two aspects to be stated at the outset in order to understand the significance of socio-cultural factors in the low cost housing environment. Firstly, home making is more critical in low cost housing environment for the sheer lack of space and the constraints caused by standardization of design. Due to this, the outdoor near-home space of low cost housing area plays significant role in complementing the dwelling and supporting the home making endeavor. Secondly, such processes, in turn, constitutes an important component that generates of the vitality and social life of the otherwise dreary housing environment. [5] and this is what urban design obligation is about.

2.2 Socio-cultural features of housing

Beside the physical context, the residents of a low cost mass housing also need to confront the social contexts in order to create their home place. The high density condition of such housing compels residents to engage in or regulate

interactions with the people living close by. Social interaction plays a substantial part in defining how an individual regards the housing environment and experiences the home. Social context also provides potential social support and social network particularly important in low income community. What constitutes social network however is largely dependent on the way the people think, social norms and lifestyles together with culture. Social and cultural factors shape an integral relationship in most areas of housing as Chiu (2004) argues. Rapoport (1990) defines culture as “people’s ability to effectively interact”. Many researchers believe that socio-cultural matters are integral part of residential environment since it defines the way settlers behave and use resources [6].

Socio-cultural concept however includes following:

- Achievement to understanding culture, identity, values, norms and lifestyles of target groups and their inter relation
- Involve related groups in determining priorities, design, implementation and evaluation of development projects

While a fragment of artificial environment called housing plays an important role in sustainable development of the cities, sustainability of its own is totally depended on intertwined social, cultural and economic aspects. In the way that sustainability could be accounted as social preconceptions that are necessary to support environmental sustainability.

Accordingly urban design defines the relationship between artificial environment (buildings, streets and plazas) and socio-cultural structures that are critically correlated. [7] Generally two main scenarios exist to express the way people link

themselves to affordable housing: firstly by means of kinship and tradition, they interact, secondly the perspective that argues they socialize based upon personal interests. To meet the needs of the earlier, urban designers should consider collective needs of settlers, and to meet the latter needs they have to put less stress on sense of community by which sustainable social relationships won't shape.

2.3 Mass affordable housing in Iran

Looking at after revolution period, mass housing projects entered Iran in terms of 5 years programs. It wasn't until the third program that housing found its status as an independence part. Promotion of using concrete, generation of prefabricated industries in large cities, land use efficiency and financial resources reinforcement have always been emphasized by the programs. Some of them providing residential needs of the people inside the city as "Land Preparation Projects" others however generated residential complexes in suburbs by which rough housing environments created. The new housing complexes outside the cities have always lack identity, safety and social network formation. In these programs each stage have had its particular goals while no one reached to optimum stage as once anticipated due to lack of facility and not being accepted by the users. The procedures continued until the latest mass affordable housing called Mehr project, siting kindness as a core strategy. Despite construction of 28000 housing units and large budget allocation, quality criteria remained unsolvable similar to previous projects. Many experts slammed it as "a small house made on a large land". Satellite housing, unmixed dwelling of low income people, high density housing in suburbs, monotonous and lifeless spaces were practically a significant failure for the superficially true decision.

Mehr housing projects are constructed within 2 phases: firstly technical matters such as excavation and making buildings structures are implemented by cooperative companies. Elaboration of houses such as tiling and coloring is partially conceded to the owners as citizen partnership in the second stage.

2.3.1 The common problem

Lack of shaping identity for environment as well as settlers as a substantial crisis is accounted as the most outstanding issue in the newly constructed residential complexes of Iran. The factor that has always been underestimated despite highlighted attention to basic needs.

As noted short-term dwelling is the primary intersection of all dwelling groups in housing projects of Iran. The users seeking an opportunity to immigrate or displace while others have to stay and modify their housing environment to comply with their lifestyle needs. Investigations have made it clear that most of the groups have short-term planning (5-10 years) since have not accepted the new complexes or towns as their home place. [⁸] the new housing projects are of similar spatial as well as physical structure while locating around the country known as the land of diversity .consequently the new projects has not met socio-cultural demands of the contexts. Though urban design perspective that highlights user-oriented design is able to fill such gaps [⁹]

3. Research Methods

One of the most significant methods to study user-environment compatibility is to observe and analysis of settlers behavior in exterior housing environments [¹⁰]. The main method used in this paper is a descriptive analysis relying on observation and inhabitant background study through which people aspiration in public spaces enclose.

In detail the paper was undertaken by analyzing 2 selected public spaces of Manzarieh and the use of qualitative research methods. The main data collection is conducted using the ‘unobtrusive observational method’, which tracks human behaviors in space through ‘disguised field analysis’ Numerous repetitions of similar observations are undertaken at different times of the day and night in order to increase the validity of the results and given suggestions. The repeated behavioral tracking of the 2 selected public spaces of Manzarieh with different uses and activities are analyzed based on ‘evaluative observational variables’ to ensure valid conclusions based on collected observations [11] Observation of pedestrian behavior together with historical records of Bakhtiary community are carried out to complement what do the inhabitants preconception about Manzarieh housing environment. The interview approach may not be responsive for these environments since people may not tell the truth either due to lack of trust to local government or counsel.

4. Analysis & Results

4.1 The case study: Introduction

Province of Chaharmahal-o-Bakhtiary is accounted as one of those located in mountain area in center of plateau Iran. Shahre-Kord in which Manzarieh is located at northeast, is the highest city due to its 2150 meters altitude while being capital city of the province. (fig.1)

People of the province are classified into two ethnics, the so called Chaharmahali (with Persian and Turk ethnics) and Bakhtiary (Lor ethnic) with most of them from Bakhtiary ethnic.

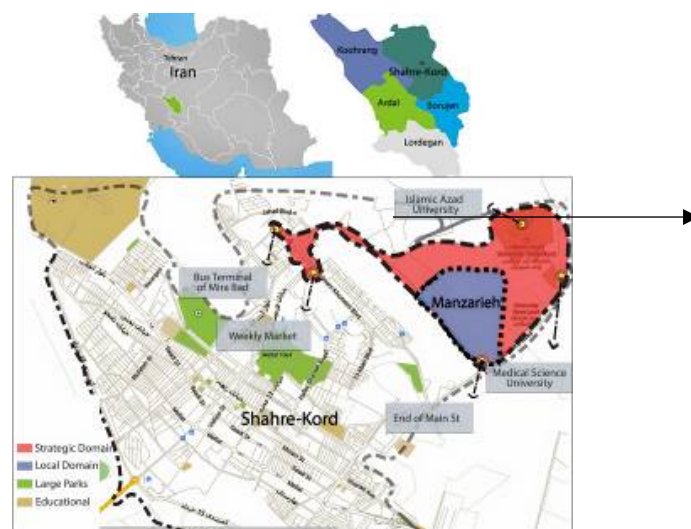


Fig.1: Important places in the vicinity of Manzarieh

There are number of significant elements including the two universities, weekly market, main road and bus terminal that affecting Manzarieh local domain and introducing strategic scale domain. Being affected by production methods diversity, Bakhtiary crafts are various and outstanding by some of them known as global such as woodcarving and locksmith (fig.2)



Fig.2: Chaleshtor's Lock, accorded recognition as identity heritage by UNESCO

Traditional economy of Shahre-kord's people is based upon handy crafts such as carpet weaving, felting and gathering then drying herbs. These activities however has transmitted to the women these days to help family economy. Most of men working on industrial sectors, some still preserving their historic activities such as farming.

4.2 Socio-cultural background of Bakhtiary community

Archaeological findings have illustrated that Bakhtiary community as a Persian ethnic originates in Shushtar around 6th or 7th century B.C. [12] the province has been under Caliphs ruling system. Historical surveys have elucidated that Bakhtiary community with Khans at the head have had a cohesive social as well as ethnic system due to particular Geographical and ethnic territory.

In terms of settling traditions, most of historic residential buildings made by Bakhtiary community are elaborated with woodcarving, colorful sashes with coarse and fine glass pieces, ornamental plastering together with close relationship with nature configured the way they resided.



Fig.3: Sotoude house (up). Amir Mofakham fortress (down). Source: historic heritage office of Chaharmahal-o-Bakhtiary 2006



Symbolic elements such as “stone lion” as the sign of territory defining for houses or villages are abundant in their history and collective memory as a common phenomenon.

More luxurious houses have however referred to Khans in form of fortresses with being larger and more luxurious, siting their

courage and gallantry in hunting, equitation and archery.

The community has had various ceremonies established in different times of the year. Some communal to national ceremonies including grieving in Ashura or in time of a dear life lost or Norouz ceremony in which people visit each other despite being in hostility while wearing new dresses.

Various beliefs have associated with their lives, affecting their behavior in routines and are part of their culture. The beliefs are inherited from one generation to other, some of which include:

- A green tree with foliage on it shouldn't be cut.
- They have an especial attention toward color of green, they wear green bands on their wrist
- Their lengthy and loud greetings are well-known
- They accentuate kinship relationships



Fig.4: traditional Bakhtiary's women wearing (left) and men (right)

They have had special kind of clothes either for women or men (fig.4). Having numerous as well as intertwined social units is one of outstanding features of Bakhtiary's social structure. Such a social units are environments in which the real solitary is happening whether in conflicts or in their routine productive activities. In terms of economic activities, pastoralist and agriculture has been core activity of them in the past century. Many of Manzariéh residents remain the same beliefs and the way their ancestors lived as is observable in the case study.

In addition to 4 residential pieces of 33, 61, 39 and 47 hectares, there have been cultural, religious, sport and urban facilities that have been considered for this new residential complex, although some of them not being constructed yet. In this 180

hectare area there are 6770 housing units built, while some parts are under construction. This provides dwelling for 27124 individuals mostly from Bakhtiary community mixing with Chaharmahalis.



Figure 5: construction phases of Manzarieh. (Selected public spaces are illustrated)

5. Discussion & Conclusion

This paper relies on the observational survey from urban design point of view along with study of socio-cultural records of Manzarieh inhabitants to give some indications about socio-cultural aspiration of the people. The analysis below is a summary of findings of these observations. The current section of the paper would look into the spatial behaviors within the newly constructed Manzarieh public realm in order to identify indicators for socio-environmental values. The two selected public spaces are the most congested places in Manzarieh with the first one located in the center of the complex with the main commercial uses and the second chosen space near the main mosque of Manzarieh. Pedestrian movement pattern locating was carried out by some architecture students of

Azad university of Shahrekord who volunteered contributing to the research.

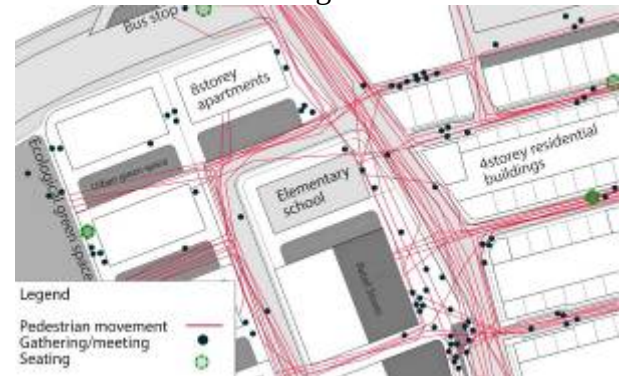


Fig 6: The behavioral analysis of selected space no.1

By observation, public space no.1 seem to be “active” in terms of human activities with most of retailing premises located here. Aside from being most accessible, the location of Imam Hassan elementary school behaving like a focal point for the area.

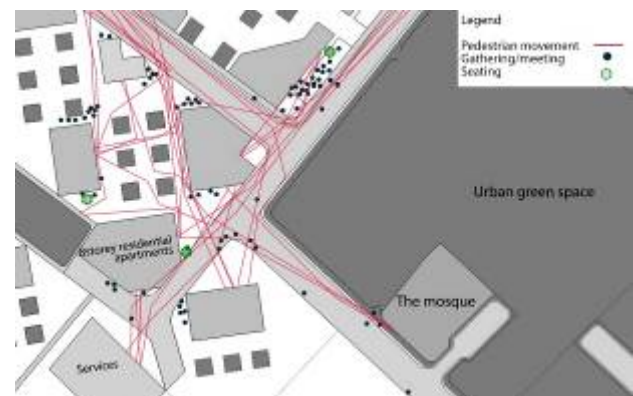


Fig 7: The behavioral analysis of selected space no.2

The second public space with Imam Hadi mosque located in the southern part, characterizes with 8-10 story apartments, settling most of Bakhtiary ethnic. Both sites portray by vast monotonous asphalt areas together with modern delineation apartment buildings, raising no spatial potential for socio-cultural activities.

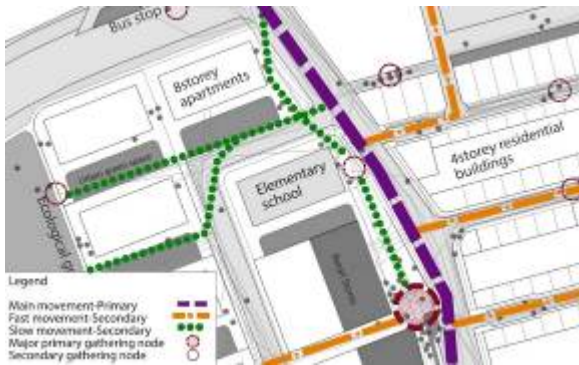


Fig 8: The movement analysis of selected space no.1



Fig 9: The movement analysis of selected space no.2

As is illustrated in public space no.1 the primary movements occur in front side of the 8storey apartments with the gathering points mostly alongside of the blocks. In space no.2 retail stores at the eastern side remain the major gathering/meeting point while the northern edge (front side of the 8storey blocks) acts as transient route. The number of people interacting with vegetation feature (at the southern edge) rises significantly in normal weather conditions in western part of public space no.1.

The movement paths of pedestrian is mostly found through front areas of the blocks (where is expected to be a gathering point mostly) while the stationary activities occur in the side edges of 8storey blocks.

The use pattern of both selected spaces reveal that the socialization related activities, frequently occur in ecological areas (compliant with bakhtiari/Charmahali background) In 8 story residential areas however, the spaces between the point towers is the place

that many women socialize and children play as observed. This is the case for men in night times while women inside. Apart from these busy locations, the internal residential enclave areas are less active in terms of socialization activities as observed. Interestingly, numerous meetings/gathering nodes of women along with children playing areas occurs in condominium inner spaces of 8 story apartments of public space no.2 (mostly stairs). However this is not the case in the 4storey apartments in public space no.1 with most social activities happening in their blind communal alleys by women of Charmahali flatter a rug and sitting in the alleys.

The 3 mosques of Manzarieh are strategically located within the new town. However they do not act as focal points and look deserted in times of praying, even in holy days of mourning.

Global and local spatial integration of Manzarieh was analyzed using Depthmapx with various attributes illustrated in fig 10 to compare expected pedestrian behavior with the real for both selected spaces.

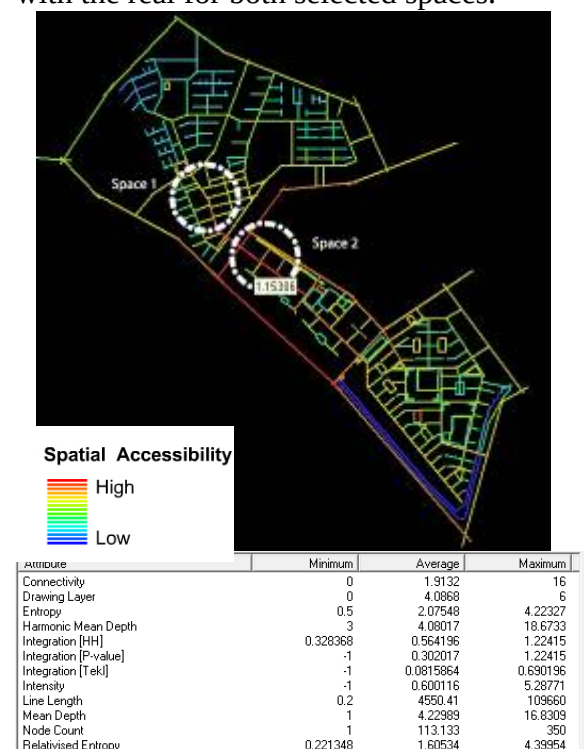


Fig 10: Global spatial integration analysis of Depthmap

As space syntax theory states, the most human movement and activities occurring in spaces with higher spatial accessibility (from blue for least accessibility to red for the most). Predictably as shown in global spatial integration the 3 red lines in the middle of the compound embrace higher human congestion with various activities (movement/stationary). Meanwhile in local scale, the two red lines expected to have most human activities along with retail and other movement depended uses in them.(with retail stores in space no.1 and Imam Hassan mosque in no.2.)

As observed main pedestrian routes occur in the linear space with IV 10 as expected. Though there are gathering points and transient routs in the blue areas (IV average 4) in space 2, outside the most integrated spaces. In space no.2, the highest integrated spaces are dedicated to residential enclaves with pedestrian movement the same as surrounding streets as illustrated in fig7.



Fig 11: Local spatial integration analysis for first space (up) and the second (down)

In terms of global spatial integration, most of alleys with less IV, Having least movement pattern while trigger more stationary activities (gathering/meeting) as observed and illustrated in fig 7&8. This issue highlights Bakhtiary people tendency to socialize in spatially isolated spaces rather than integrated, perhaps due to Chaharmahalis presence in their territory. Aside, social isolation of the people in Manzarieh is also affected by environment design. As illustrated in global IV, clustering design of residential area has resulted in zoned land uses and separated movement in a socially mixed compound.

5.1 Socio-cultural background

While there are large amount of wastelands in the area, number of retail stores are inadequate with respect to access radius (about 1.2 kilometers in northern areas) and roads steep as well. This is more highlighted when it comes to Bakhtiary habits to buy their daily needs of retail stores rather than at once. In terms of access paths arrangement, settlers of Manzarieh apparently are in favor of housing developments with no vehicle traffic inside since they believe strangers coming to heart of their colony having a particular purpose. The configuration of access roads has led to lack of any speed reduction mechanism for the vehicles coming inside the enclaves. Dead end alleys in multifamily parts of the complex, are accounted as great places for informal interactions in which women gather and socialize by carpet flattening and sitting in the alleys with their children playing around. The form of socializing also is classified into women and men by presence of women in public spaces in groups at the time of men's absence and vice versa. This case is not typical socialization way in Bakhtiary ethnic. These issue resulting in lack of social mix and its benefits.

Being typical urban scenario of Manzarieh, the most balconies and verandas in both selected spaces literally used for woman

economic activities (such as drying and selling vegetables or making handy crafts). It is common in Manzarieh and other areas of Shahre-kord for women to help family economy with secondary activities. Particular spaces are needed to do so, such as cuisine or greenhouses. Absence of such spaces together with small home plans, has resulted in transformations by changing balconies to the place of herbal flattening, cloth drying, making handy crafts or so, using temporary structures.

These temporary structures in some cases are a response to privacy especially near main roads due to their religious beliefs to cover against strangers, while the solution has led to natural air ventilation prohibition in some cases.

While semi-public spaces have always played a significant role in previous houses with wide porch functioning as a joint, open to close spaces ratio is not of proportionate amount and it is now confined to “pokey apertures” in Bakhtiary language.

In terms of urban form, the two selected compounds lack physical symbols and elements, compatible with inhabitant historic image, displacing with monotonous environment covered with pale yellow bricks, free of Shahre-kord traditional architecture. Even the names of the places do not originate in the people culture and history that brought them to call spaces in numbers not the names of the martyrs as is. Many of the residents have come from cities with ethnic rivalry and conflict. Everyone knows his or her territory in such environments. While in Mehr housing projects there is inevitably coexist in multistory apartments with no privacy defined and no attachment to the place is formed. The consequence marks ignoring environment maintenance by dumping waste materials in public spaces and the conflicts caused by so, except for lower rise multifamily parts that marking their common public spaces with planting.

5.2 Participation and economic support
Mehr housing projects are constructed in a way that owners have no participation in the process. On one hand, shaping social cohesion is a challenge due to the way housing units are conceded. Various organizations concede their exclusive housing units to their own employee. On the other hand students of the University of Shahrekord have recently renting some particular areas of the complex, contributing to social exclusiveness in some parts.

In terms of socio-cultural education, no enterprise or supportive organ is doing a favor to remain and declare culture, traditional habits and local arts of Bakhtiary residents of Manzarieh that could promote economic, consequently social status of Manzarieh.

Social anomalies act as another issue in absence of citizenship behavior. In some cases breaking lighting equipment and damaging public facilities, also graffiti are accounted as teenager hobbies while there is no learning materials neither in public spaces nor public media for education matters.

This paper has analyzed the socio-cultural situation of one of the cases of national wide Mehr affordable housing project within Shahrekord from observational urban design point of view. It should be noted that at this stage the research is based only upon an observational survey along with background study, which may not be exactly representative of the whole population. However, it should be enough to provide some indications about the socio-cultural aspirations of the people. Along with compulsory settling in the area, it is noted that Bakhtiary people have remained their traditional life style and trying to adopt with the new unaccountable built environment. Children and women are another lost fragment in the design of public realm in this project.

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OPTIMIZATION SIZING AND PLACEMENT DISTRIBUTED GENERATION WITH DETERMINATION NETWORK RECONFIGURATION AND CAPACITOR BANK SIMULTANEOUSLY TO MAXIMIZE ACTIVE POWER OUTPUT OF DISTRIBUTED GENERATION USING GENETIC ALGORITHM METHOD

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Abstract

The demand for electricity continues to increase in line with the growth of population but it is not matched with adequate power generation. Distributed Generation (DG) is one of the solutions to increase the availability of electrical energy which is able to accommodate the development. DG is able to supply additional active power in distribution network but less precise placement may result in less optimal active power output of DG. Therefore, this paper presents reconfiguration of the network, DG and capacitor optimal placement using Genetic Algorithm (GA) either sequentially or simultaneously to be tested on a modified IEEE 69 buses radial distribution system. The test showed that the optimization techniques in network reconfiguration, DG, and capacitors placement simultaneously are able to increase the bus voltage profile to satisfy the constraint. The minimum voltage limit on the optimization is 0.98537pu.

Keywords: *Active Power, network reconfiguration, the placement of Distributed Generation (DG), capacitor placement and Genetic Algorithm (GA).*

1. Introduction

Society interest about clean and eco-friendly renewable energy has caused distributed generation technology being the focus of many researches lately. The growing of electricity demand and the complexity of distribution system raise system losses with poor voltage regulation. According to the research, the losses in distribution system could reach nearly 10 – 13 % of generated total power. This fact leads to increasing energy cost and poor voltage profile. The commonly used method of voltage stability and power drop in the distribution system are network reconfiguration, DG and capacitor placement. The DG itself basically a power generation which is spread and connected to the main distribution network. The spread power generation is

commonly renewable energy such as wind turbine, micro hydro, and solar photovoltaic (PV). Thus, each unit of distributed generation is not always able to supply power to the main grid continuously. Therefore, a DG unit status is different with one another in the certain time. Network reconfiguration, DG and capacitor placement can maximizing profit and reduce the loss of power system.

Distributed generation is a small sized power generation (commonly in several KW until tens MW). The DG which is not part of the main generation is often located near the load. The use of DG increases since its important role in the power supply. DG utilization has brought some benefits related to its high efficiency, small size, modular capability, and close location with the energy source [1].

In previous research, the effect of DG placement towards power losses and network reliability is studied using Genetic Algorithm. In this paper, Genetic Algorithm is used to determine the location of DG and capacitor as well as network reconfiguration on modified IEEE 69 busses. Optimization of DG sizing and location, as well as a capacitor, are done under bus voltage constraint. Under this constraint, DG and capacitor are located on the certain bus without exceeding the maximum and minimum voltage limit. In [3], network reconfiguration, DG and capacitor placement which is done simultaneously could reduce power losses and improve bus voltage. This method has better result compared to separately applying network reconfiguration, DG and capacitor placement.

2. Literature Review

The generally used distribution network is the radial system. This system has a simple form and low investment cost meanwhile its service quality is relatively poor. In several past years, electricity industry has changed significantly in the distribution system, mainly because of incremental distributed generation technology application. Distributed Generation (DG) is defined as decentralization of power generation by placing smaller generation unit which is closer to the load. The effect of DG placement in the system depends on location and size of DG. Therefore, this paper focuses on the examination of several cases using an effective method to perform network reconfiguration as well as DG and capacitor optimal placement [4], [5].

A. Radial Distribution System

Radial system is commonly used in the distribution system. In this system, the line is drawn radially from a source point and branched out to load point. Thus, the form of the system seems like tree branches with the main line connected to

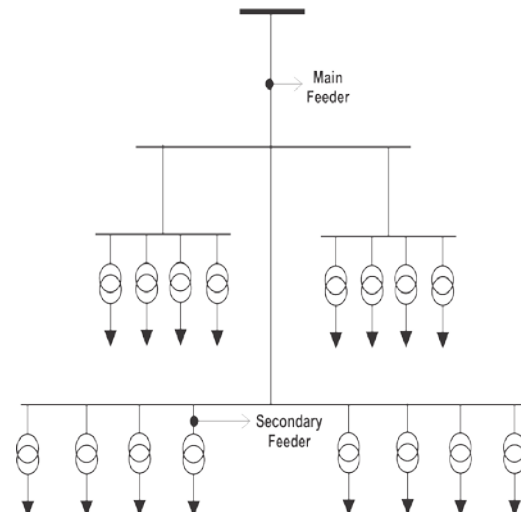


Figure 1. Radial Distribution System

the smaller circuit towards the load. The topology is shown in Figure 1.

The advantages of using radial distribution system are its simple topology and low investment cost. Meanwhile, the weakness of this system is relatively poor service quality caused by high losses and voltage drop. Furthermore, the continuity of power distribution is less reliable. In this system, CB, sectionalized, recloser and other load switch are used to localize fault. This system has a little modification, such as tree type radial system, a radial system with tie-switch, a radial system with load center, and radial system with phase-distribution.

B. Network Reconfiguration

Network reconfiguration is one of the optimization technique in the distribution system. In order to reconfigure the network, tie switch and the sectionalizing switch is opened. The network reconfiguration increases the network operation specifically leading to voltage and power quality improvement. Thus, the operation of distribution system can be done with minimum cost.

Optimization searching method can be used to obtain and determine tie switch and sectionalizing switch status. Currently, many methods have been used in

optimization of reconfiguration, such as PSO, BPSO, GA, and so on.

C. Placement & Sizing Capacitor

According to reference [3], one of the methods to regulate and improve bus voltage is placing paralleled capacitor on distribution busses along a line or between substation and load. Basically, the capacitor is used to produce reactive power in the mounting point. The capacitor can be connected permanently, however for voltage regulation capacitor can be removed to satisfy load dynamics.

Placing capacitor parallel with lagging loads causes the capacitor to behave as a source for supplying a part or all of the reactive power needed by loads. Therefore, the capacitor can be used to reduce current flowing towards loads and decrease voltage drop. Generally, the amount of reactive power and price per unit can be taken into notice in capacitor placement.

D. Placement & Sizing Distributed Generation

Distributed Generation (DG) is small power generation placed close to the load point. DG has the potential to be used for reliability improvement either directly or indirectly. By placing DG, local voltage level can be increased and blackout can be prevented.

DG has several types of forms and modular capability, such as micro hydro, photovoltaic, wind generation and diesel machine as well as battery. Generation capacity of DG could be classified into several categories as shown in Table 1.

Table1. Distributed Generation (DG) Classification based on Generation Capacity

DG Type	Generation Capacity
Micro DG	1 Watt – 5Kw
Small DG	5kW – 5MW
Medium DG	5MW – 50 MW
Large DG	50MW – 300 MW

E. Genetic Algorithm

Genetic Algorithm method (GA) utilizes natural selection process as knows

as evolution process. In the evolution process, individual continuous experience gen mutation to adapt to the environment and only the best individuals could survive.

This method can help solving problems in power system. Generally, the coding is done in binary to arrange a string which forms gens composed chromosome. The solution and best fitness are searched according to desired objective function. The parameter for this methods is a generation, pop size, crossover probability, and mutation. Random generation will be chosen by the genetic operation (selection, crossover, and mutation). The operation result will be evaluated based on objective function, thus the chromosomes used in the next iteration are obtained to perform other iteration.

3. Research Methods

A. IEEE 69 Buses Radial Distribution System

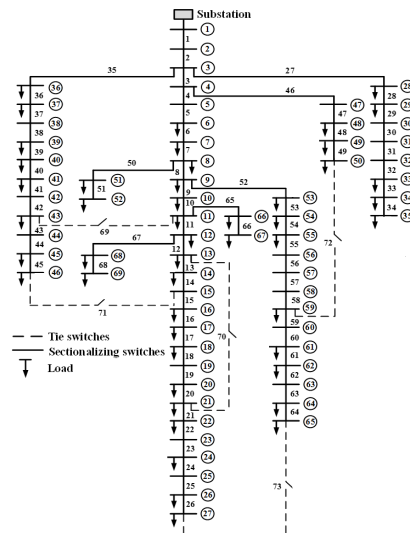


Figure 2. IEEE 69 Bus Single line diagram

IEEE 69 Buses with 5 tie switches is used as a plan in this works. The total amount of active and reactive power is 5,55 MW and 3,96 Mvar. Figure 2 shows the single line diagram of modified IEEE69 Bus.

B. Study Case

In this works, several cases have been conducted to evaluate each

optimization technique and learn its effect toward reactive power output of DG. The conducted study cases are :

a) Modified IEEE 69 Buses Standard System

This case is performed to obtain bus voltage condition in the system before performing optimization technique

b) Network reconfiguration

In this case, network configuration is performed by closing the tie switches and opening sectionalizing switches however the system topology is kept to be radial.

c) Distributed Generation (DG) Placement

This case is conducted only by placing DG.

d) Distributed Generation (DG) and Capacitor Placement

This case is done by placing capacitor and followed by performing DG placement.

e) Simultaneous Network Reconfiguration and DG Placement

Network reconfiguration and DG placement are done simultaneously

f) Sequential Network Reconfiguration, DG and Capacitor Placement

This case is conducted sequentially. The optimization is performed by placing DG and capacitor first then followed by network reconfiguration.

g) Simultaneous Network Reconfiguration, DG, and capacitor Placement

The optimization of network reconfiguration, DG, and capacitor placement are done simultaneously.

C. Objective function

The objective function is a goal of optimization or the desired result. The objective function and some constraints of this work are maximalizing active power output of DG as written on Equation (1) – (4),

$$\text{Maximize } F(x) = \sum_{i=1}^{N_{DG}} P_{DG_i} \quad (1)$$

Where,

P_{DG} i-th of DG output power

N_{DG} number of DGs placed in the system

Each optimization has a constraint as criteria to determine the solution and fitness. Several constraints in this works are :

Voltage constraint

$$0.95 \text{ pu} \leq V_i \leq 1.05 \text{ pu} \quad (2)$$

Constraint active power injection (P MW) of DG

$$\sum_{i=1}^{N_{DG}} P_{DG_i} \leq \sum_{j=1}^{N_l} P_D(j) \quad (3)$$

Constraint reactive power injection (Q MVar) of capacitor

$$\sum_{i=1}^{N_c} Q_c(i) + \sum_{i=1}^{N_{DG}} Q_{DG}(i) \leq \sum_{j=2}^n Q_D(j) \quad (4)$$

D. Design of Component and GA Parameter

In Genetic Algorithm method, there are several components and parameters which are set based on the problem or desired optimization. The following table shows the design of components and GA parameter to the maximizing active output power of DG in the radial distribution system.

Table 2. Representation of component and GA Parameter to maximizing DG active power

GA	Explanation
Gen	1 and 0 binary code
Chromosome	Group of gens (Consisting of optimization solution) Network Reconfiguration (tie switch and sectionalizing switch status)
	Capacitor (Placing and Sizing reactive power injection) DG (Placing and Sizing active power injection)
Population	The number of Chromosome in a group (the amount of solution) = 50
Objective Function	Optimization Goal (Maximizing DG active output power) $Maximize F(x) = \sum_{i=1}^{NDG} P_{DGi}$
Max Generation	The number of regeneration or generation result of mating = 100
Crossover	Cross mating (PC = 0.95)
Mutation	Mutation (PM = 0.05)

E. Simultaneous Reconfiguration, Capacitor and DG Placement

Coding binary is conducted based on optimization technique and applied plan (IEEE 69 Buses). The following figure shows binary coding and decoding chromosome.

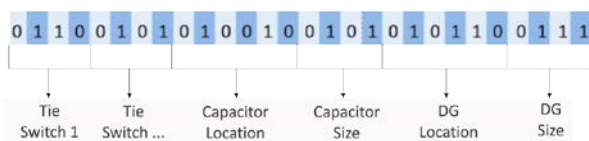
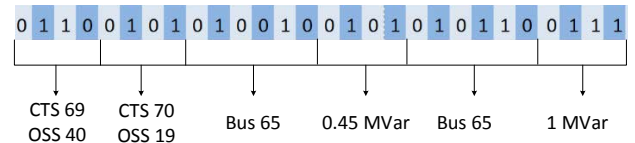


Figure 3. Example of Gen GA

Chromosome in Simultaneous Reconfiguration, Capacitor, and DG Placement



Note : CTS (Close Tie Switch)
OSS (Open Sectionalizing Switch)

Figure 4. Example of Chromosome Decoding in Simultaneous Reconfiguration (tie switch n), 1 capacitor and 1 DG

$$GA = \begin{bmatrix} OS_1^1 & OS_1^2 & OS_1^3 & OS_1^4 & OS_1^5 & Cap_1^1 & Cap_1^2 & Cap_1^3 & DG_1^1 & DG_1^2 & DG_1^3 \\ OS_2^1 & OS_2^2 & OS_2^3 & OS_2^4 & OS_2^5 & Cap_2^1 & Cap_2^2 & Cap_2^3 & DG_2^1 & DG_2^2 & DG_2^3 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ OS_n^1 & OS_n^2 & OS_n^3 & OS_n^4 & OS_n^5 & Cap_n^1 & Cap_n^2 & Cap_n^3 & DG_n^1 & DG_n^2 & DG_n^3 \end{bmatrix}$$

Rekon Cap Placement DG Placement

Figure 5. Simultaneous Population Optimization of GA

F. Optimization Process Using Genetic Algorithm

Generally, optimization process using Genetic Algorithm (GA) is performed with the following steps:

1. Data and Parameter Reading

The first process is data reading of modified IEEE 69 Buses distribution system in form of line data, bus data, tie switch, and GA parameter as well as another parameter

2. Initiation Load Flow

Initial load flow is done in order to know the initial condition of the system before performing optimization. Thus, initial bus voltage, reactive power (MVar), and active power (MW) of the system can be obtained. The value of that parameter will be used as

standardization value and power injection limit of capacitor and DG.

3. Generating Population

The generated population size depends on the desired optimization, such as 10, 20, 50, and so on. The population is generated randomly which has binary value. Furthermore, Ns-bit from each chromosome is set based on the desired case.

4. Decoding Chromosome

All chromosome will be parsed based on conducted case. Later, all chromosome in population will be decoded to obtain an initial solution.

5. Evolution

In this process, random selection, crossover, and mutation are conducted to obtain offspring. The evolution process will be repeated until the determined generation is reached.

6. Evaluation

The offspring which experience genetic mutation from the parents will be decoded in order to obtain a solution. The solution will be applied in modified IEEE 69 Bus system before conducting Load Flow. From load flow result, voltage minimum limit can be obtained and will be saved in fitness 1.

7. Best Fitness

After evaluation, the selection of individual which has the best fitness is conducted based on constraints. Thus, the selected individual can satisfy the criteria or constraints and has the best fitness. This individual has a solution from optimization case.

4. Analysis & Results

This part presents the result of simulation and analysis using the genetic algorithm as well as forward – backward load flow analysis on distribution system 69 buses IEEE standard. This work is divided in several cases :

Case A : existing condition analysis (without optimization and conditioning system)

Case B : reconfiguration only

Case C : DG placement

Case D : DG and capacitor placement

Case E : reconfiguration and DG placement

Case F : reconfiguration, DG, and capacitor placement sequentially

Case G : reconfiguration, DG, and capacitor placement simultaneously

The result from simulation and analysis will be compared with all of the cases to obtain the best case. In this simulation, the used DG and capacitor are three units. DGs are set to supply active power (P) meanwhile the capacitor supplies reactive power (Q). In this paper, the radial distribution system is applied on 69 buses system IEEE standard. The topology of the system is shown in Figure 2.

Simulation and analysis result :

The following Table 3. is optimization result case A until case G.

In the case of A, the result shows that there are many under voltage on several buses and the worst voltage is 0.86354 p.u. Case B (conditioning using reconfiguration) changes topology of network distribution on the system without DG and capacitor placement, the result for case B still obtains several under voltage bus condition, but voltage value is higher than case A. Case C (conditioning using DG placement), there are 3 installed DG which capacity 0.9322 MW for DG 1, 0.0632 MW, for DG 2 and 2.1488 MW for DG 3. Where the power output of each DG will be optimized by Genetic Algorithm (GA) method. For the case D, the system will be added and installed capacitors with capacity 0.1725 MVar for Capacitor 1, 1.2798 MVar for Capacitor 2, 1.8012 MVar for Capacitor 3. Similar to the case C, using Genetic Algorithm (GA) method to determine that location and size DG and

capacitor. Case E (reconfiguration of the network and the installation of DG simultaneously), network reconfiguration and installation of DG performed simultaneously. Reconfiguration of the network in the condition closed or open on tie switch and sectionalizing switches, DG installed three units with capacity 0.237 MW for DG1, 1.6274 MW for DG2, 1.2798 MW for DG3. Case F and G (reconfiguration of the network, installation of capacitors DG and both sequentially or simultaneously). For the location determination, DG and capacitor of case F and G are same. As for the case G, DG and capacitors are installed each DG with capacity 0.0632 MW for unit DG1, 0.5846 MW for unit DG2, 2.3226 MW for unit DG3 and 0.6785 MVar for unit capacitor1, 0.1725 MVar for unit capacitor2, 1.4375 MVar for unit capacitor3 with optimization using Genetic Algorithm (GA) is able to produce the best solution, whether it generates the corresponding bus voltage constraint or as the allowable limits and generates maximum active power of each DG.

DG and capacitor placement and network reconfiguration either sequentially or simultaneously have a difference in search results and best fitness solution, but simultaneous techniques are better than the sequential techniques. Due to the simultaneous optimization has more variation possibility of incorporation than sequential techniques, can be observed in Figure 3 and Figure 4.

5. Discussion & Conclusion

On the basis of the system, there is a bus under voltage condition. With the installation of DG and capacitors as well as the reconfiguration of the network using genetic algorithm obtained improvements bus voltage.

Placement 3 DG units on bus 22, 58, 63 and 69 produce a maximum active power output till 3.14 MW.

Table 3. Optimization result case A - F

Case	Comparative Study Of Different Case Studies	
Base Case (Case A)	Min.Voltage (p.u)	0.86354
	Max.Voltage (p.u)	1
	Bus Worst	65
Only Reconfiguration (Case B)	Close Tie Switch	71, 72, 73
	Open Sectionilizing S	12, 57, 64
	Min.Voltage (p.u)	0.92682
	Max.Voltage (p.u)	1
	Bus Worst	64
Only DG Placement (Case C)	Min.Voltage (p.u)	0.954052
	Max.Voltage (p.u)	1
	Bus Worst	27
DG, Cap Placement (Case D)	Min.Voltage (p.u)	0.9677
	Max.Voltage (p.u)	1
	Bus Worst	61
Reconfiguration with Simultaneously DG (Case E)	Close Tie Switch	69, 70, 72, 73
	Open Sectionilizing S	18, 42, 57, 61
	Min.Voltage (p.u)	0.96314
	Max.Voltage (p.u)	1
	Bus Worst	61
DG,Cap with Recon (Case F)	Close Tie Switch	71, 72
	Open Sectionilizing S	13, 56
	Min.Voltage (p.u)	0.97973
	Max.Voltage (p.u)	1
	Bus Worst	61
DG,Cap with Recon Simultan (Case G)	Close Tie Switch	71, 72, 73
	Open Sectionilizing S	12, 25, 53
	Min.Voltage (p.u)	0.98274
	Max.Voltage (p.u)	1.013
	Bus Worst	24, 25

Placement 3 DG units and capacitors, able to increase the bus voltage. Likewise with the network reconfiguration and placement 3 DG units sequentially. The voltage value still satisfies the constraint.

Reconfiguration, DG placement, and capacitors, able to increase significantly the bus voltage with merge the three techniques, and it is the most optimal technique. Especially it for which simultaneously.

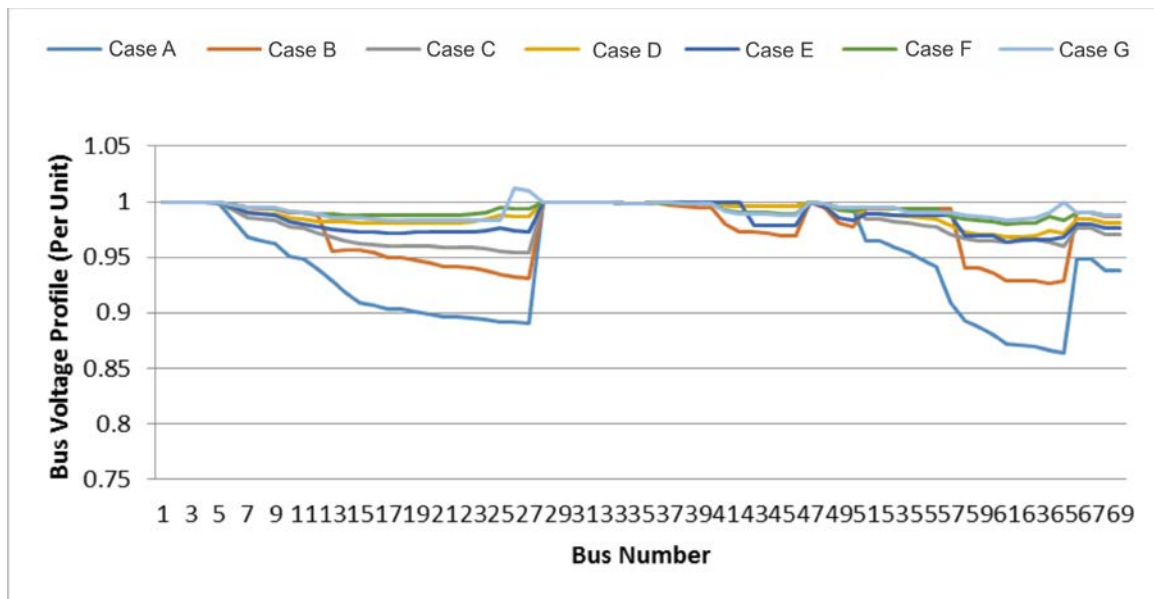


Figure 3. Comparison Voltage Profile each case

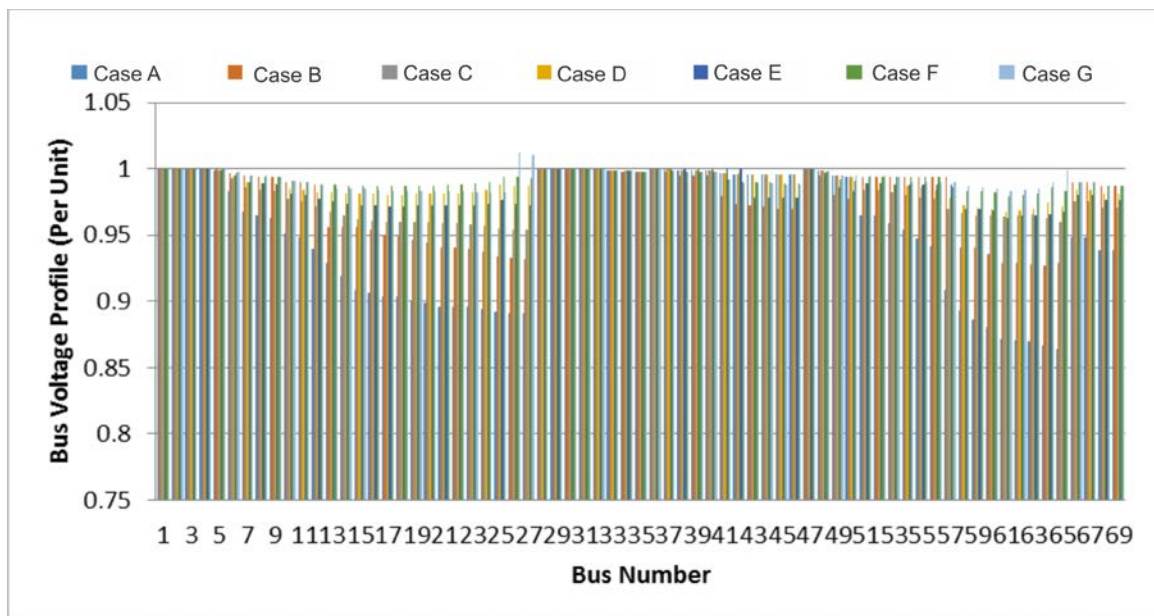


Figure 4. Comparison Voltage Profile each bus and case

The difference in technique sequentially and simultaneously is the manner of the optimization process method. Optimization is performed per-sequential optimization techniques meanwhile simultaneous performed concurrently.

Genetic Algorithm (GA) was able to produce an optimal solution to determine the place and size DG active power output in order to obtain maximum DG. Likewise

with reconfiguration network and capacitor placement.

6. Acknowledgment

We gratefully acknowledge financial support from Penelitian Disertasi Doktor-Kompetitif Tahun Anggaran 2016 (Project No.: 01802/IT.11/PN.08/2016) KEMENRISTEK-DIKTI, Indonesia.

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APPENDIX

TABLE AI

LOAD DATA OF 69-BUS DISTRIBUTION SYSTEM

Bus Number	P _L (kW)	Q _L (kVAr)	Bus Number	P _L (kW)	Q _L (kVAr)
6	2,60	2,20	37	26,00	18,55
7	40,40	30,00	39	24,00	17,00
8	75,00	54,00	40	24,00	17,00
9	30,00	22,00	41	1,20	1,00
10	28,00	19,00	43	30,00	21,50
11	145,00	104,00	45	39,22	26,30
12	145,00	104,00	46	195,00	131,50
13	40,00	25,00	48	79,00	56,40
14	8,00	5,50	49	384,70	274,50
16	45,50	30,00	50	384,70	274,50
17	60,00	35,00	51	40,50	28,30
18	60,00	35,00	52	3,60	2,70
20	1,00	0,60	53	4,35	3,50
21	570,00	405,00	54	26,40	19,00
22	5,00	3,50	55	24,00	17,20
24	28,00	20,00	59	500,00	360,00
26	14,00	10,00	61	1244,00	888,00
27	327,00	262,00	62	32,00	23,00
28	26,00	18,60	64	227,00	162,00
29	26,00	18,60	65	295,00	210,00
33	14,00	10,00	66	18,00	13,00
34	19,50	14,00	67	18,00	13,00
35	30,00	20,00	68	28,00	20,00
36	26,00	18,55	69	140,00	100,00

TABLE AII

BRANCH DATA OF 69-BUS DISTRIBUTION SYSTEM

Branch Number	Sending end bus	Receiving end bus	R (Ω)	X (Ω)
1	1	2	0,0005	0,0012
2	2	3	0,0005	0,0012
3	3	4	0,0015	0,0036
4	4	5	0,0251	0,0294
5	5	6	0,3660	0,1864
6	6	7	0,3811	0,1941
7	7	8	0,0922	0,0470

8	8	9	0,0493	0,0251
9	9	10	0,8190	0,2707
10	10	11	0,1872	0,0619
11	11	12	0,7114	0,2351
12	12	13	1,0300	0,3400
13	13	14	1,0440	0,3450
14	14	15	1,0580	0,3496
15	15	16	0,1966	0,0650
16	16	17	0,3744	0,1238
17	17	18	0,0047	0,0016
18	18	19	0,3276	0,1083
19	19	20	0,2106	0,0690

TABLE AII (Continued)

Branch Number	Sending end bus	Receiving end bus	R (Ω)	X (Ω)
20	20	21	0,3416	0,1129
21	21	22	0,0140	0,0046
22	22	23	0,1591	0,0526
23	23	24	0,3463	0,1145
24	24	25	0,7488	0,2475
25	25	26	0,3089	0,1021
26	26	27	0,1732	0,0572
27	3	28	0,0044	0,0108
28	28	29	0,0640	0,1565
29	29	30	0,3978	0,1315
30	30	31	0,0702	0,0232
31	31	32	0,3510	0,1160
32	32	33	0,8390	0,2816
33	33	34	1,7080	0,5646
34	34	35	1,4740	0,4873
35	3	36	0,0044	0,0108
36	36	37	0,0640	0,1565
37	37	38	0,1053	0,1230
38	38	39	0,0304	0,0355
39	39	40	0,0018	0,0021
40	40	41	0,7283	0,8509
41	41	42	0,3100	0,3623
42	42	43	0,0410	0,0478
43	43	44	0,0092	0,0116
44	44	45	0,1089	0,1373

45	45	46	0,0009	0,0012
46	4	47	0,0034	0,0084
47	47	48	0,0851	0,2083
48	48	49	0,2898	0,7091
49	49	50	0,0822	0,2011
50	8	51	0,0928	0,0473
51	51	52	0,3319	0,1114
52	9	53	0,1740	0,0886
53	53	54	0,2030	0,1034
54	54	55	0,2842	0,1447
55	55	56	0,2813	0,1433
56	56	57	1,5900	0,5337
57	57	58	0,7837	0,2630
58	58	59	0,3042	0,1006
59	59	60	0,3861	0,1172
60	60	61	0,5075	0,2585
61	61	62	0,0974	0,0496
62	62	63	0,1450	0,0738
63	63	64	0,7105	0,3619
64	64	65	1,0410	0,5302
65	11	66	0,2012	0,0611
66	66	67	0,0047	0,0014
67	12	68	0,7394	0,2444
68	68	69	0,0047	0,0016

Tie line

69	11	43	0,5000	0,5000
70	13	21	0,5000	0,5000
71	15	46	1,0000	0,5000
72	50	59	2,0000	1,0000
73	27	65	1,0000	0,5000

OPTIMIZATION OF PANEL PV POSITION USING DUAL AXIS SOLAR TRACKER WITH PERTURB AND OBSERVE METHOD IN PV TOWER - LABORATORY SCALE MICROGRID SYSTEM

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Abstract

PV systems should be designed for optimum power efficiency. Add a solar tracker to follow the position of the sun, it can optimize PV position. In this paper, MPPT method Perturb and Observe (P&O) will be adopted and implemented in a mechanical system of the dual axis solar tracker. P&O Method is considering the value of power that implemented into the microcontroller where the current and voltage sensor as the input, which is expected to make the position of PV panels on both axes are optimal, so it can maximize the power generated from PV systems. The analysis was then performed by comparing the value of the energy produced by the dual axis solar tracker system with fixed PV or non-optimization. The results of this experiments are the increasing percentage of 19.43% of the energy produced by PV panels. This method will be excellent when used for larger scale of PV system.

Keyword: Photovoltaic System, Dual Axis Solar Tracker, Perturb and Observe, Microcontroller, Arduino UNO

I. Introduction

As one of the renewable energy sources, solar energy is getting a lot of attention from various parties, especially to replace fossil fuels dwindling and pollution they cause. One of the utilization of solar energy is the conversion of solar radiation into electrical energy using solar cells or photovoltaic. PV system itself is a promising technology that is clean, environmentally friendly and has low maintenance costs [1]. However, the cost of an expensive investment and the value of low efficiency is still an obstacle for the PV system is to be used widely for the general public.

There are three different ways that can be used to improve the efficiency of the PV system: improving and developing materials design solar cell makers; using MPPT or

Maximum Power Point Tracker to address the nature of voltages and currents that are not linear from the PV itself; and optimizing the position of PV by adding a tracking device to follow the direction of the sun motion [2]. On the first way, silicon is the best semiconductor material which is used for producing a solar cell. But the material itself limits the efficiency of the PV cell, so to develop the performance of PV cells through good materials require long-term research which is not cheap [3].

On the second or static way, PV panels track the value of voltage or current to locate the point of maximum power from the PV panel itself. MPPT technique requires additional tools such as converters and continuous adjustments due to constant changes in environmental conditions. On the third or dynamic way, a device is used to make solar

tracker PV panels perpendicular to the sun so that energy is transferred from the panel to the system will be maximized.

Research on the solar tracker is developed based on a changing position of PV panels that will affect the output power of PV panels. In trials that have been done in previous studies, the changes of the position and angle of PV panels prove that the position of the PV panels greatly affects the output power of the PV panels themselves as a result of changing irradiance and temperature which is received by the PV panels [4].

In this paper, MPPT method Perturb and Observe (P&O) will be adopted and implemented in a mechanical system of the dual axis solar tracker. The expected value of using this method is to produce the most optimal position for both axis (x and y) of PV panel. Attaining the optimal position of the both axis is expected to be able to maximize the power which is generated by PV system.

II. Literature Review

A. Solar Cell

Basically, the solar cell is a diode semiconductor. When positive-negative junction from the diode exposed by the light there will be an energy conversion from light energy to the electricity. Where energy from the photon is enough to release the outer bonding of the electron in that material.

The current flows will occur when the solar cell is in short circuit condition with a load.

The ideal model of a solar cell.

Mathematically is showed in Equation (1).

$$I = N_p \cdot I_L - N_p \cdot I_o \left[\exp \left\{ \frac{q \left(\frac{V}{N_s} + I \cdot \frac{R_s}{N_p} \right)}{a \cdot n \cdot k \cdot T} \right\} \right] - \frac{V \cdot \frac{N_p}{N_s} + I \cdot R_s}{R_{sh}} \quad (1)$$

I = Current in the output (Ampere)
 I_L = Current produced by solar cell

I₀ = Reverse saturation current
 Q = Element Load
 V = Voltage between output terminal
 R_s = Serial resistance
 N = Diode ideal factor
 K = Boltzmann Constant
 T = Absolute temperature
 R_{sh} = Shunt resistance
 N_p = Number of parallel solar cell
 N_s = Number of serial solar cell

Before PV panel connected to the load, a PV will produce an open circuit voltage (V_{oc}) when the terminal of PV is being shorted the value of I_{sc} will occur. When a real load is connected, there will be a power that occurs because of the combination of current and voltage where the value depends on the characteristic of V-I. Maximum power value is a peak point from the end of I-V where it is a result of multiplying the maximum current with the maximum voltage (I_m and V_m)

The value of PV will be maximum when it is on the condition below the full sun (the sun at 1.0) When its characteristic is at the half, so the PV current will be reduced in the ratio of the radiation intensity of the sun, with the lower value of the irradiance (sun radiation) so the characteristic of I-V will be reduced too.

The curve of I-V characteristic depends on the irradiance PV panel, consist of many serial connected PV cells. When half of the PV panel is shadowed, the result will make a voltage loss, but it still needs to be loaded by the panel current. The shadowed section of the panel will not produce any power, in fact, it will give a load to the system and bring losses I²R and heat. So the other PV section must work at a higher rate to cover the losses. Higher voltage value at the good PV will show lower current value at I-V characteristic curve. So when the losses exceed the critical point, the I-V curve will be at the under of the operation voltage. It will make the current drops, and make the panel lose all the power.

The effect of the shadowed section in a PV panel. With fixed current value, the voltage drops to ΔV

When we see from the material of the PV, the percentage efficiency that we got from converting the sun energy to the electricity with the PV panel with Mono-Si material a class in this PV panel is 15% until 18%. Besides that, for each PV module, the produce will supply some of the performance parameters, for example, it is the PV output rating where the value is produced by the STC condition with the value of the irradiance is 1000W/ 1.5, and the PV cell temperature is 25 Celsius

But in the reality, STC rarely occurs and almost impossible. So, the maximum rating will be difficult to be realized. By the literature [9] with the variation condition of the sunlight by the earth rotation, and by the effect of the clouds who could cover sunlight, the average power that produced by the PV panel is about 20% from its nominal power, within a year. That value could drop by 16% within 20 years because of the degradation of the PV material by 0.5% each year by its nominal power, although we do maintenance periodically.

B. Solar Tracker

A solar tracker is a device that is used for keeping the PV panel at its optimum place which is perpendicular by the sun radiation so it can increase the power collection. [12]

There is 2 main type of solar tracker, defined by its axis movement: single axis solar tracker and dual axis solar tracker. This 2 type is divided again by the technology of the tracking system, active, passive and chronological.

In single axis solar tracker, the tracker needs to follow the daily rotation of the sun from east to the west by its altitude. When dual axis

solar tracker needs to follow the azimuth and the altitude.

A passive solar tracker is designed for the thermal value of PV material, it will move by the response of the unbalance pressure between two points of the tracker caused by the heating process of the cell structure.

Active solar tracker moves by using a microprocessor and electrical-optical sensor to define its best position which is perpendicular to the sunlight.

For chronological tracker, it moves by the uniform value of the PV panel.

By the [14] literature, the percentage of the efficiency in the solar tracker can be analyzed by its increased power, current, average voltage with this formula as shown in Equation (2).

$$\% \text{efficiency} = \frac{\text{optimization value} - \text{non optimization value}}{\text{optimization value}} \times 100\% \quad (2)$$

By [15] literature, to define the tracking effect of the PV system, we could use the efficiency formula as shown in Equation (3).

$$\eta = \frac{ET - (EF - EC)}{EF} \times 100\% \quad (3)$$

ET is the energy produced by the tracking system, EF is the energy produced by the fixed PV, and EC is the consumed energy by the tracking system.

C. Maximum Power Point Tracker

The I-V characteristic of PV module is not linear, it only has an operation point that produced maximum output. But, the maximum point is constantly changed by the intensity of sun radiation and temperature. To obtain an optimal value, we need to do Maximum power Point Tracker (MPPT) method [16].

The MPPT method(s) is defined by its complexity, the number of sensors, the convergence speed, number of hardware, etc.

Basically, the mechanism of the MPPT method is how it automatically looking for voltage V_{mpp} or Current I_{mpp} , so the maximum power can be obtained.

Some of MPPT methods are Hill Climbing or Perturb and Observe, Incremental Conductance, Fractional Open Circuit Voltage, Fractional Short-Circuit Current, Fuzzy Logic Control, etc.

D. Perturb and Observe

Perturb and Observe or Hill Climbing Starch, is a popular MPPT method because of its simple algorithm which needs a low priced microprocessor. This method periodically giving disturbance (increase or decrease) the voltage value or current to the PV panel and comparing its power output to the previous power output. When the power output is increased the disturbance will be given continuously to the same movement. Vice versa when it's decreased, until they will have maximum power point.

E. Microcontroller Arduino UNO

UNO Arduino Board is a microcontroller hardware that is integrated with IDE software. Microcontroller itself is a microcomputer in an IC (Integrated Circuit) which is consist of core processor, memory, and programmable intergrade.

Arduino UNO is divided into 2 big parts: the Arduino UNO Board, and the IDE software.

The board is a hardware that is used to build an object, and the IDE software is a special program that is used to command the Arduino UNO board with simple languages modeled by processing languages. When upload command is pressed, the languages will be translated to the C languages and forwarded to the microcontroller as a command.

III. Research Methods

A. Dual Axis Solar Tracker based on Perturb and Observe Method (P&O)

P&O method that will be used for the solar tracker, is adopted by P&O method that uses in electronic control charging named Maximum Power Point Tracker (MPPT). The difference of this two method is the interference or the other word perturb as seen in Figure 1. Perturb In the dual axis solar tracker system based on P&O method is meant DC motor movement to lead PV panel position both on x or y-axis to get an optimal position. With this, optimal power can be achieved. Voltage and current are produced by PV panel which will be sensed to be input in Arduino UNO microcontroller. This input will be processed in accordance flowchart (to be described later) for the next gave command actuation to DC motor via the motor driver.

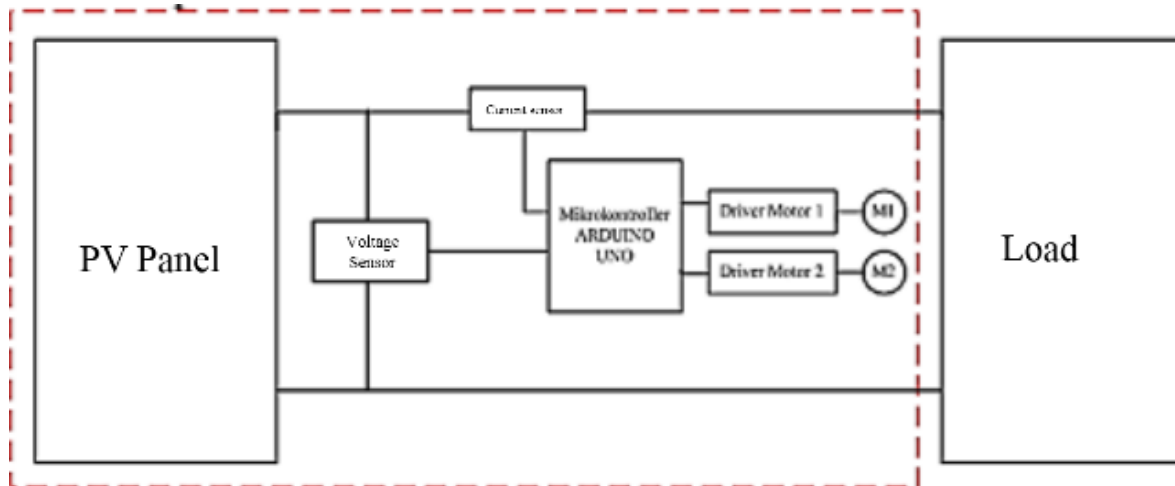


Figure.1 Diagram Block Dual Axis Solar Tracker Based On Peturb and Observe Method

The mechanical system consists of some equipment, there are two motor DC, PV framework with two axis movement, charge controller, and battery as power conservator. Current that flow from PV to the battery will be sensed by the current sensor and send to be processed in the microcontroller. Plant PV consists of two identical panel mounted in parallel. Detail of PV Panel Spesification is shown in Table 1.

Table 1. PV Panel Spesification

Specification	Value
Manufacture	CALTECH
Solar Module Type	SP – 200 W
Output Power (P_m)	200+5%W
Max Power Voltage (V_{mp})	36.459V
Max Power Current (I_{mp})	5.491A
Open Circuit Voltage (V_{oc})	44.706V
Short Circuit Current (I_{sc})	5.740A
Max Operating Voltage (V)	1000 V _{DC}
Cell Technology	Mono-Si
Application Class	Class A
Standard Test Condition	25°C, 1.5AM, 1000W/m ²

Dual axis PV used tower with a height of 2 meters above ground. The tower is used to avoid shadow form building and trees. The operation of solar PV used two degrees of freedom, there is axis x and axis y, which can make PV panel can be rotated and shift up and down [22]. Two DC motor as actuators of dual axis solar tracker systems based method P&O arranged by utilizing the polarity of the

DC motor for movement [23]. To make the system can generate operating current value, used the load in the form of batteries that were previously connected with charge controller. Electrical system used in this system is current and voltage sensor, motor driver, and microcontroller. Sensors will be used to retrieve the value of current and voltage and will be processed in the microcontroller to control two DC motor. A current sensor that used is ACS 712 hall current sensor 30A [25]. Voltage sensor that used is voltage divider with output 0 – 5VDC. This value is adapted to microcontroller analog capacity. Motor driver used in this system is EMS module with 30A H-bridge current capacity [27]. This module is used for handling motor rotation speed and directional control accordance with instructions of the program in Arduino UNO microcontroller.

The system design software is used to designing the logic of the algorithm used P&O as well as the allocation of the control system I/O pins on Arduino UNO Board microcontroller as a center data processing system.

Input-output configuration Pin used for operating are

- Analog Pin 0,1 : current and voltage analog signal
- Digital Pin 2,5 : output signal for direction motor A
- Pin digital 3,6 : output signal PWM

- Pin digital 4,7 : output signal for direction motor B

Flowchart of the control command system scheme of the dual axis solar tracker based P&O method is as shown in Figure 2.

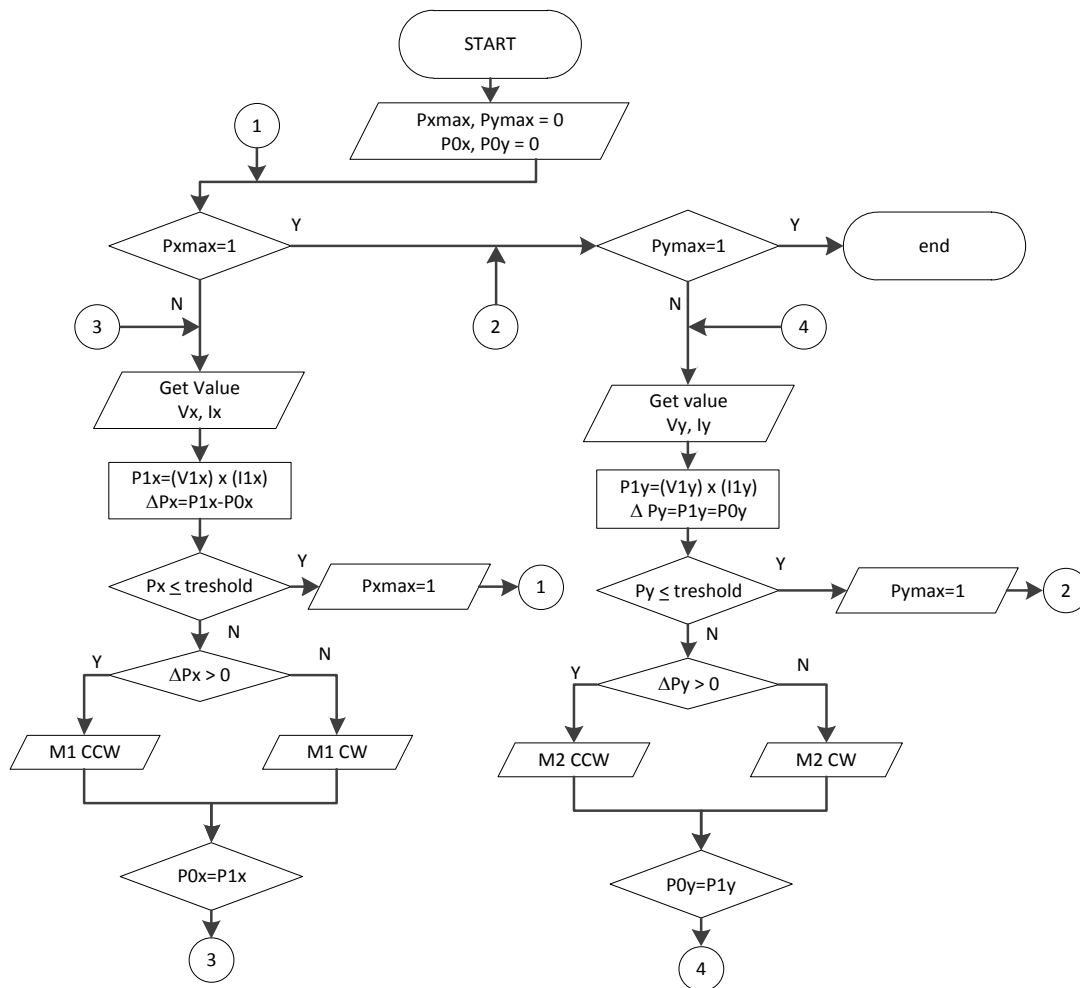


Figure 2. P&O Algorithm for Solar Tracker

Start from current and voltage data acquisition that obtains from output PV voltage and current that flow from solar PV to the battery through the charge controller. From two variable, the number of power can be calculated. The value of power is compared with the previous. If the value is outside from threshold PV panel will change the position. This action resulting in a change of voltage and current values. Movement of

the PV panel based on the comparison of power. If the power calculation from current and voltage is higher than the value before and between the threshold, the microcontroller will order motor DC to stop. Otherwise, PV panel will rotate and shift the position until the power value within the threshold and can be considered the PV panel

have reach maximum and the difference can be tolerable (to avoid oscillations). If the power value on the x-axis has a maximum value, then followed on the y-axis method the same one.

IV. Analysis & Result

The experiments were performed on the same day and the same weather conditions with time interval 1-hour start from 09:00 until 15:00. Then the results of the data that retrieved and monitored from serial monitor [28] IDE Arduino built into graphical form as shown in Figure 3.

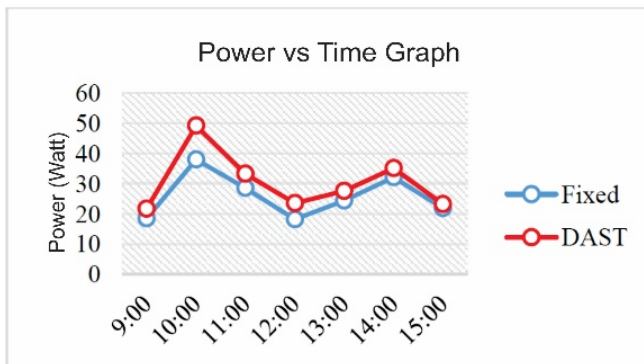


Figure 3. Power vs Time Graph for Fixed PV compared to Dual Axis Solar Tracker based P&O method



Figure 4. Fixed PV Position



Figure 5. PV Position after Optimization with Dual Axis Solar Tracker based P&O method

The percentage of increasing power efficiency for dual axis solar tracker system based P&O method compared to without optimization of fixed PV for each hour of the day can be seen in the following graph as shown in Figure 6.

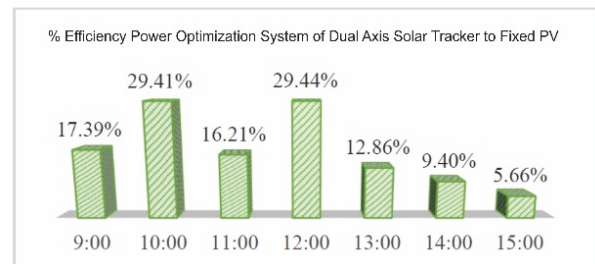


Figure 6. Power efficiency graph in system with Dual Axis Solar Tracker compared to Fixed PV per hour

To determine the effect of tracking the performance of existing PV system, it can be done by finding the value of energy efficiency as shown in Table 2.

Table 2. Comparison value of Energy with Optimization and without it.

	Energy (Wh)
Fixed PV (without optimization)/ E_f	229.37
Dual Axis Solar Tracker based method P&O (optimization) / E_f	273.94

By performing optimization system with dual axis solar tracker based P&O method, the efficiency energy can be increased by 19.431% or equal to 44.57 compared to without optimization. Performance of optimization system in real time is showed as in Figure 4 and Figure 5. Thus value still can be increased by improving the PV conditions. The influential factor of that value is the location of PV tower which is able to cause a partial shading and also the efficiency of the material itself.

V. Discussion & Conclusion

In this paper, PV panel position optimization analysis using dual axis solar tracker based on Perturb and Observe (P&O) method on the laboratory scale microgrid system has been showed. P&O method on electric MPPT can be applied on the dual axis solar tracker. This method can improve and optimize current, voltage, and PV power for 15.4%, 3.01%, and 19.431% respectively with power differences up to 44.57Wh. The efficiency of PV vary depends on materials, performance, and material degradation. Within this result, it can be concluded that P&O method is decent to apply for its simple algorithm and real-time operation.

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SOLAR PV MODEL FOR ECO-GARDEN AND HYDROPONIC DAILY WATERING SYSTEMS

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Abstract

Supplying water for eco-garden and hydroponic system using solar photovoltaic system is one of the best way to provide the need of water requirements for daily watering. This paper presents a method that can be used for sizing and modeling Solar PV system for eco-garden and hydroponic system. The model described how to predict the capability of the pump to pumping water, predict the flow rate per hour to meet the daily needed. It used ac centrifugal pump, dc pump, a voltage inverter, and battery storage. The experimental result also provided to calculate the accuracy of the model.

Keywords: *Solar PV system, Eco-garden, Hydroponic system, Pumping water*

1. Introduction

Indonesia is the country that has a lot of potential renewable energy. One of the most potential renewable energy in Indonesia is solar energy because Indonesia passes through equator line. Ministry of energy and mineral of Indonesia in 2015 reported that Indonesia has 112 GW potential of solar energy. [RUKN ESDM 2014]

Photovoltaic (PV) is the device that can convert solar radiation into electricity using photovoltaic effect. Solar photovoltaic systems can provide electricity to supply electrification and water pumping systems. Water pumping is a crucial need in several regions in Indonesia. Hundreds of PV systems have been installed for irrigation, livestock, and domestic need, it's proofed that PV system can provide an economical and reliable method how to meet the demand of hydraulic requirements.

In this paper, we will design Solar PV water pumping system to supply water for

eco-garden and hydroponic system in SD IT Al-Uswah Surabaya, Indonesia. In this case water waste from wudhu can be reused for watering eco-garden and hydroponic system using renewable energy from Solar PV System.

2. Literature Review

Photovoltaic pumping system used for the water reservoir in Algeria village irrigation service areas has been designed by Nabila, Louai, Fouad Khaldi, and Mounir Aksas [1]. The design of the system was made to replace conventional diesel generation technology that has been used. It provides modeling, simulation, and optimization of pump system based solar generation.

The size of pump system based solar generation have been determined by Acakpovi, Amevi, Fifatin F. Xavier, and Robert Awuah- Baffour [2] through analytical method. That method gives us a reference in applying this system.

The theoretical calculation and experimenting pump system based solar generation has been done by Hamrouni,

Nejib, Moncef Jraidi, and Adnène Chérif [3]. The result from it can help us defining system specification that will apply.

Photovoltaic pumping system used in supplying water for drink, clean water, and micro irrigation on destitute socialism in Nepal, has been applied by McLaughlin, Fintan, Aidan Duffy, and Michael Conlon [4]. The paper becomes our reference calculating technical and dynamic of economic considering local characteristic environment, physic, and social economy on each area

Caracas, João Victor M., Luis Felipe M. Teixeira, G. D. C. Farias, and L. A. D. S. Ribeiro [5] has implemented high-efficiency converter and low cost on pump system solar-based generation. To determine optimal specification on applying installation pump system, we used it as the reference.

3. Research Methods

3.1. Water Pump Sizing

The first step designing of solar powered water pump system is determining the size of water tank required for the operation. The amount of water to be pumped is 5100 Liters or equal to 5.1 m³.

Considering the height of water canal between the water tank and water utilization, the height is 15 meters, the size of the water pump can be obtained. The water pump size is 300 Watt.

3.2. PV Array Sizing

PV Array sizing depends on the total system load, which means the determination of total wattage of the water pump. Considering the efficiency inverter 90%, the operating factor 0.75, and mismatch factor 0.85. [1]

$$PV \text{ Array size} = \frac{300}{0.9 \times 0.75 \times 0.85} = 522,876 \text{ Watt}$$

Six 100 WP, 24 V solar panels need to be used for this application. Table 1 shows data given by the manufacturer for 100

WP, 24V Photovoltaic panel. The rated peak power (100 WP) is available only at STC such as cell temperature at 25°C and insolation of 1000 W/m².

Table1. Parameters of the 100Wp PV module.

Specification	Value
Manufacturer	CALTECH
Solar Module Type	SP-100-P36
Output Max Power (P_{max})	100 ±5% W
Current at P _{max} (I _{mp})	5.69 A
Voltage at P _{max} (V _{mp})	17.6 V
Short-Circuit Current (I _{sc})	6.09 A
Open-Circuit Voltage (V _{oc})	22.6 V
Temperature Range	-45°C +80°C

3.3. Pumping System

Electrical power is generated by six parallel photovoltaic modules. Parallel modules generate total current bigger, at the same voltage level than series modules. The output power of photovoltaic modules controlled by solar charge controller, before stored into the battery. Solar charge controller stabilizes the output voltage of PV module. The inverter converts the output power of battery from DC current become AC current, then energize the water pump. The water pump is utilized to irrigate the hydroponic farm on the rooftop of a building.

4. Analysis & Results

During the simulations, the models were tested with changing speed that change with illumination. The simulation was prepared considering the characteristics of the Solar Panel, installed on the roof of the SDIT Al-Uswah, and using the characteristic of the pump unit in the Garden as shown in Figure 1. The inverter is controlled by DVC technique. We choose for a nominal frequency of 50 Hz and The models of maximum power point tracker electric are closed-loop constant V/Hz control. Simulation results by without load and with considering one induction motor (Pump) are presented by several cases.

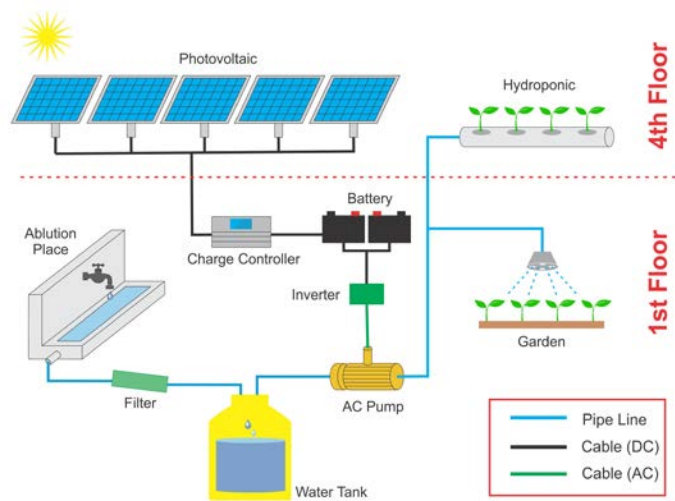


Figure 1 . Solar PV System Model for Eco-Garden and Hydroponic Systems

Case -1: Without Load

In this simulation, we do not install load in this panel, only solar panel, MPPT and battery in Table 2 can be seen how maximum current and voltage in one day, then can know about current charging solar panel to battery.

Table 2. System Simulation Without Load

Time	Output Solar PV (V)	Output Solar PV (Amp)	Input Battery (V)	Input Battery (V)
08:00	20.9	14.03	13,58	14.03
09:00	20.9	17.50	13,58	17.50
10:00	20.9	20.12	13,58	20
11:00	20.9	20.15	13,58	20
12:00	20.9	19.05	13,58	19.05
13:00	20.9	16.69	13,58	16.69
14:00	20.9	13.12	13,58	13.12
15:00	20.9	9.90	13,58	9.90
16:00	20.9	6.10	13,58	6.10
17:00	20.9	5.80	13,58	5.8
18:00	20.9	0.50	13,58	0.5

After that, to validation this circuit, it's safe and can use to turn on pumping this research use emergency test and measuring how many current and voltage in this system. Table 3 explain about measuring how much current and voltage in DC power and AC power. DC power is the Solar panel

to Battery and the next to inverter than AC power is the inverter to induction motor (pump) and in this simulated system is not connected to load. Solar PV modelling is installed as shown in Figure 2.

Table 3. Result Experiment of System

Case (sec)	Solar Panel Output (Amp)	Battery input (Amp)	Battery output (Amp)
1	19.5	15.5	2
2	19.5	15.5	2
3	19.5	15.5	2
4	19.5	15.5	2
5	19.5	15.5	2

In Table 4 can see about how configuration about the emergency in this system.

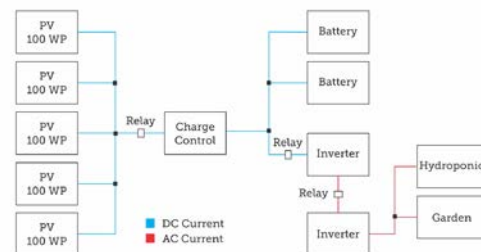


Figure 2. Solar PV Modelling

Table 4. Configuration of Emergency System

Case 1	S1	S2	Lamp	Emergency
Batery	On	Off	Orange	Off

Pukul	Input Inverter (V)	Input Inverter (Amp)	Input Pump (Amp)	Pump (V)
08.00 – 09.00	12	21.72	1.25	220
15.00 – 16.00	12	24.43	1.4	220
Charging				
Load Running	On	On	Green	Off
System Off	On	On	Red	On
System Off	Off	Off	Red	Off/On

Switch one is connected Solar Panel to Battery then Switch two is connected the battery to inverter and inverter to load than the last Emergency can be used Switch Off all the system .

Case-2: Considering single induction motor (Pump) Consider that only one IM is connected to the SOLAR PANEL system

In this simulation we connected the load for the hydroponic daily watering system, the result of this simulation can be seen in this Figure 3.

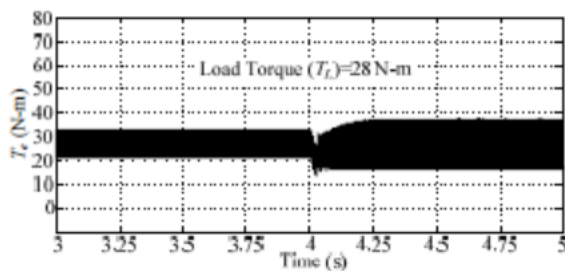


Figure 3. Response of Torque generated by the motor

The speed of the motor is dependent on the availability of Solar Panel power. At any case, the controller of IM maintains energy management between load and source. This system can show the response

of speed of IM when reduced the irradiance from 200 WP at $t = 4$ sec. However, the load torque remains same and the response of torque generated by the motor is shown in Figure 4. However, if solar power is very low that indicates reference speed of IM is below the base speed (ω_b) then the motor cannot pump the water.

Form this research for hydroponic watering system based on Solar Panel system. The simulation results demonstrate that the performance of the controllers is satisfactory under steady state as well as dynamic conditions.

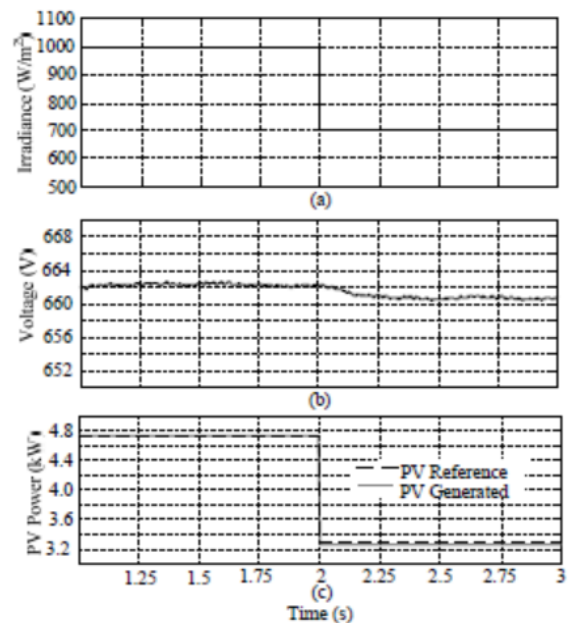


Figure 4. (a) Solar irradiance; (b): V_{mpp} or V^*_{dc} ; (c): SOLAR PANEL Power

5. Discussion & Conclusion

Solar PV System is installed in parallel mode as to adjust the voltage of the inverter, 12volt and maximize charging

current. At 10.00 am until 11.00 am, the charging current is maximal, 20.12 – 20.15 ampere. When the pump water is connected to the solar panel system, the inverter absorbing power about 260.64 – 293.16 watt. The pump water is operated as much as twice a day, at 08.00 am until 09.00 am and 03.00 pm until 04.00 pm. As photovoltaic still, work to charge the battery power at that time.

In order to maintain the quality of work and continuity of using Solar-Water Pump, is necessary to periodic inspection and maintenance as well as their evaluation after installing that Solar-Water Pump.

6. Acknowledgment

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