SUN-SHADING DESIGN METHODE FOR MULTY-STOREY OFFICE BUILDING IN JAKARTA AT PRELIMINARY DESIGN STAGE

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ABSTRACT

The problem of controlling a built environment and creating conditions favourable to human activities (e.g. controlling the influence of climate) is as old as human civilization. Through the ages men have sought the shape of the building, to fulfil basic human needs, making a protection from the bad environment elements and provision of a favourable atmosphere. Building design has reflected, throughout its history, with the advanced solution in each period.

In fact a lot of young designer in recent time do not understand enough about this problem nor trying to learn from the past. Therefore their design became environmentally unfriendly, or if they try to solve this problem, the solutions are expensive and inefficient.

This research objective is to give a good understanding for young designer on building design using climatic approach (bioclimatic design concepts). Another objective is to provide design method to help them to achieve better solution on *sun shading* design as the implementation of bioclimatic design concepts. The final design solution is not result of a subjective trial and error process, but more as a systematic and detailed decision making process.

The *sun shading* design method consists of three stages. The first is selecting alternatives from available alternatives. The second stage is determining energy consumed for air conditioner and lighting for each selected alternative. The last stage, before final design, is determining the construction, operational and maintenance cost for the implementation of *sun shading*.

Key word: sun shading, design method, bioclimatic, energy, design criteria, design stage.

1. INTRODUCTION

Most of multi-storey buildings in Jakarta have functions as offices which operate in day time with hot tropical climate (effective temperature in Jakarta approximately 30^0-33^0 C). In the office utility, air conditioning of room absolutely needed to reduce the temperature until seize the optimal comfortable (effective temperature for optimal comfortable approximately 22^0-26^0 C). This situation occurs because thermal condition can affect to the health and work productivity (Soegijanto and friends, 1998).

Based on energy audit result in Jakarta by Energy Conservation Commission – a commission under Directorate General of Electricity and New Energy of Government of Indonesia, 1993, around 51% usage of buildings energy is used to operate air control system. In 1998, although the usage percentage for the air control system decrease until 38% (Purwoko, 1998), the number of electricity energy usage for that purpose is still high.

The efforts to reduce the energy load have been done by blocking and filtering the sunlight inside the building. In this situation, one of the approximations which can be used is the bioclimatic concept in design. According to Ken Yeang (1996), Malaysian architect which introduce his works with “Bioclimatic Skyscrapers” term, there are two justifications in the bioclimatic design concept, occupant maximally comfortable, and the usage of energy minimally. The other way which can be implemented in the bioclimatic concept implementation is **Sun Shading**.

The usage of sun shading in the multi-storey building give positive effects (as expected), and also enable the appearance of negative effects, in the comfortable and construction cost. The numbers of the positive and negative effects in the multi-storey building are different; depend on sun shading type and shape, building mass, building function, geographical position, building site condition, etc.

In optimizing of sun shading at the building, in term of comfortable and reducing cost, need to develop a design method which implemented in design process.

2. SUN SHADING CLASSIFICATION AND CHARACTERISTIC ON MULTY-STOREY BUILDING

Several types of sun shading design (Lam, 1986) which can be used in order to satisfy designing purpose can be recognized (Table 1). Those types can be grouped according to distinctive classification, based on couple of things which is connected with the sun shading performance. In the next development, those types can be enlarged by combination the basic shapes. The table below are sun shading basic shapes:

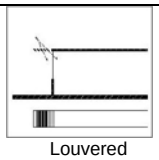
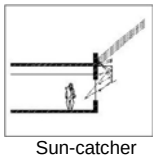
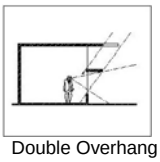
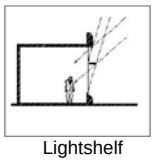
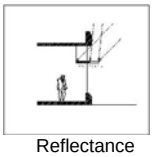
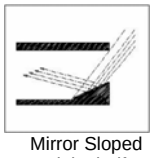
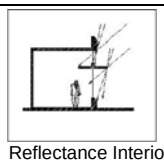
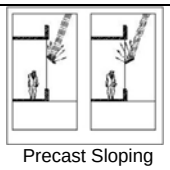
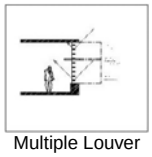
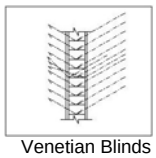
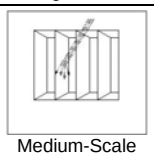
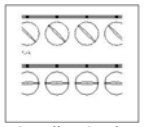
 Solid Overhang	 Louvered Overhang	 Sun-catcher	Transparent Overhang	Temporary Overhang- Awning	 Double Overhang
 Lightshelf	 Reflectance Exterior Lightshelf	 Mirror Sloped Lightshelf	 Reflectance Interior Lightshelf	 Precast Sloping Lightshelf	 Dynamic Lightshelf
 Multiple Louver Horizontal	Medium Scale Horisontal Louvers	 Venetian Blinds	 Medium-Scale Vertical Louvers	Medium Scale Dynamic Louvers	 Smaller Scale Dynamic Louvers

Table.1. Sun shading Type

Based on the types of sun shading above, sun shading can be classified as shown in the table below:

No	Classification	Sun Shading Type
1	**Based on layout position**	
	▪ ***Horizontal Sun shading***, *can directly decide the position with the sun movement specification. Usually for the East-West of the building, fixed horizontal sun shading can be effectively used.*	*Solid Overhang, Louver Overhang, Sun-catcher, Transparent Overhang, Temporary Overhang, Temporary Awning, Double Overhang, Reflectance Exterior light shelf, Reflectance Interior Light shelf, Mirror Sloped Light shelf, Pre-cast Sloping Light shelf, Dynamic Light shelf & Sun-catcher, Big Scale- Multiple Horizontal louver, Medium Scale- Multiple Horizontal louver, Small Scale-Multiple Horizontal louver (Venetian Blinds).*
	▪ ***Vertical Sun shading,*** *controlling low sun-angle but frequently be the view blocker*	*Big Scale- Fixed Vertical Sun shading, Medium Scale -Vertical Louver fixed & Dynamic, Small Scale-Dynamic Vertical Louver.*
2	**Based on move ability**	
	▪ ***Fixed Sun shading***, *The orientation cannot be adjusted*	*Almost all types of sun shading can be designed to fulfil this classification*
	▪ ***Dynamic Sun shading***, *The orientation is adjustable*	*Louver Overhang, Sun catcher, Transparent Overhang, Temporary Overhang, Temporary Awning, Mirror Sloped lightshelf, Precast Sloping Lightshelf, Dynamic Lightshetf & Sun-catcher, Multiple Horizontal louver – medium scale, Multiple Horizontal louver – low scale (Venetian Blinds), and Dynamic Vertical Louver – medium scale and Dynamic Vertical Louver –low scale.*
3	**Base on physical shape**	
	▪ ***Solid Sun shading*** *Generally, good in covering from sun light entrance*	*All types of sun shading, except Louver.*
	▪ ***Non-solid Sun shading*** *The leak of light and heat is high frequently present*	*All types of Louver*

4	**Base on relationship with the structure**	
	▪ ***Sun shading part of structural element***	*Solid Overhang, Sun-catcher, Double Overhang, and Multiple Louver Horizontal – large scale.*
	▪ ***Non-Structural element*** *Usually it's not long life*	*All types of sun shading could be part of this category*

Table 2. Sun Shading Classification

Some characteristics of sun shading based on classifications are shown below (all evaluations are held in Jakarta/ tropical area):

1. Sun Shading Characteristic Based on Comfortable Parameter

Classification base	Classification detail	Characteristic	Characteristic base
Layout direction	Horizontal sun shading	Generally good to anticipate high sun-angle, especially in the East-West direction	▪ Based on the sun shading placement direction with the ability of anticipating seasonal sun-angle (objective character).
	Vertical sun shading	Anticipate low sun-angle in the morning and evening (usually in the North-South direction)	
Shading capacity	Fixed	Anticipate daily sun-angle is not as good as dynamic sun shading	▪ Based on classification relation to ability anticipating daily sun-angle (objective character)
	Dynamic	Very good in anticipating daily sun-angle if it can be adjusted automatically	
Shape	Solid	Able to block sun light, relevant to its dimension (good in glare control)	▪ Relation to anticipate glare and the necessary of green area at the height (characteristic produced/ subjective) ▪ Relation to maintenance (objective) ▪ For non solid, based on scale, impact to view, interior and exterior, and composition & architectural proportion (subjective)
		Usually is implemented to get reflected light	
		Can be used as green area in higher place	
	Non- Solid	Cause to leak of unblocked sun light (less in glare control)	
		Large scale; generally, view is still free of sight and easier in maintenance	
		Small scale; covering view and more difficult in maintenance rather than large scale	

Table 3. Sun shading characteristic based on comfortable parameter (Note: Some of the subjective and objective characters must be measured specifically.)

2. Sun Shading Characteristic Based on Energy Consumption			
Classification base	**Classification detail**	**Characteristic**	**Characteristic base**
Based on the layout position of sun shading at the building	East (E)	Generally it's good enough to reduce the energy usage (air control) because the amount of solar energy in the East side which blocked by the sun shading	Connection with : ▪ Energy load (for air control) caused by decision of placing the sun shading in certain position (need to calculate with the computer software)
	West (W)	Generally it's good enough to reduce the energy because the amount of energy loads in the West side which blocked by the sun shading	
	North (N)	Reduce the energy because of energy load caused by sun radiation in low angle in the morning	
	South (S)	Reduce the energy because of energy loads caused by sun radiation in low angle in the evening	
	East (E) – West (W)	It's good enough to reduce the energy because high energy loads in the East-West is reduced (high sun-angle)	
	North (N) – South (S)	Reduce the energy loads caused by sun radiation in low angle in the morning and evening	
	Whole sides	Good, because it reduce the sun radiation in the whole sides but require the highest investment cost	

Table 4. Sun shading characteristic based on energy consumption parameter

3. Sun Shading Characteristic Based on Construction Parameter			
Classification base	**Classification detail**	**Characteristic**	**Characteristic base**
Shading capacity	Fixed	Long life duty cycle, operational & maintenance is easier	▪ Relation to usage age and operation easiness (objective) ▪ Difficulty in maintenance and investment cost which must be spent (objective character)
	Dynamic	Operation & maintenance is harder	
Relation to the structure	Part of structure	Rigid and long life duty cycle, in common; but limited in design (aesthetically)	▪ Has a close relevancy with structural strength, constructability and sun shading age
	Additional element	Not as strong as if part of structure, mainly in height, but flexible in design	
Possibility to use a type of material	Concrete	Cast in site or prefab system Constructability and maintenance depends on design, long life in common	▪ Relation to constructability, the age and maintenance cost (objective)
	Metal	Generally as additional element and the maintenance is harder than concrete	
	Others	Depend on another material that used	

Table 5. Sun shading characteristic based on construction cost parameter

3. SUN-SHADING DESIGN METHOD FOR MULTY-STOREY OFFICE BUILDING AT PRELIMINARY DESIGN STAGE

Sun shading is a building component (including multi-storey building), which one of the function is to make shading area to avoid the direct sun radiation to the building. In turns, the temperature inside the building will decrease, while thermal comfortable will increase.

Sun shading design method at preliminary design stage is extended development from exterior wall design in the schematic design stage. Diagram 1a. and 1b. show the process when the sun shading design is at preliminary stage.

Diagram 1a.

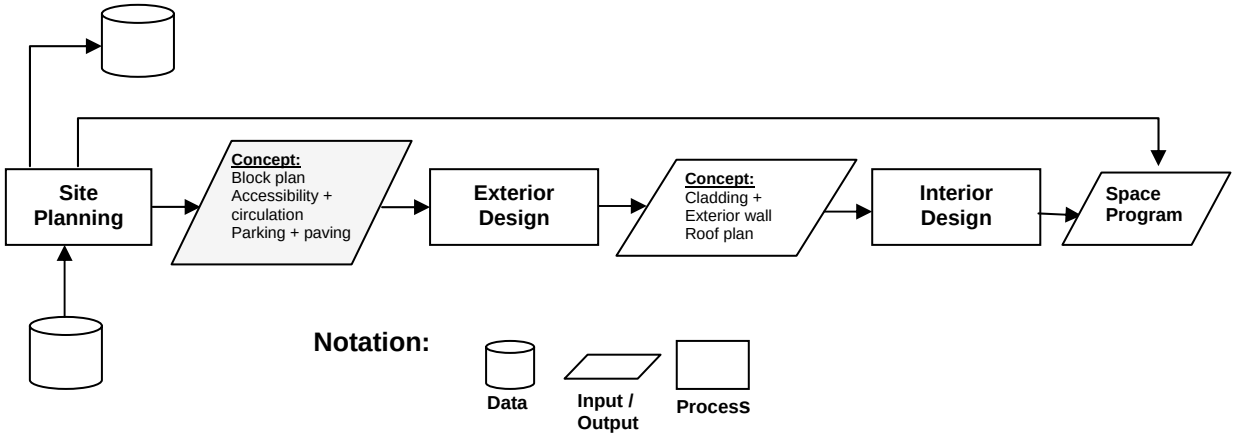


Diagram 1b.

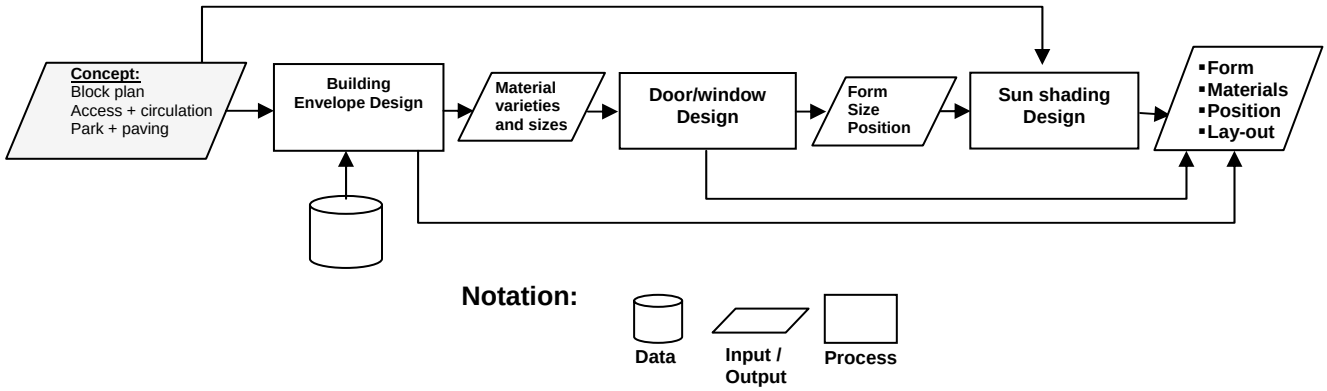


Diagram 1a,1b. Design process of sun shading at preliminary design stage.

The diagram above shows the main things which are the basic approach in the design method compilation process. They are:

1. Input-output approach process with feedback is the main and continuously process in the developing method.
2. The function consideration to define the alternative is the first consideration to gain sun shading alternative types.
3. Technological consideration in the materials is also one of the design products which are expected in the process phase.
4. Comfortable and esthetical considerations are main considerations.
5. Cost consideration with techno economy is one of the products at the edge of the process.

Diagram 2

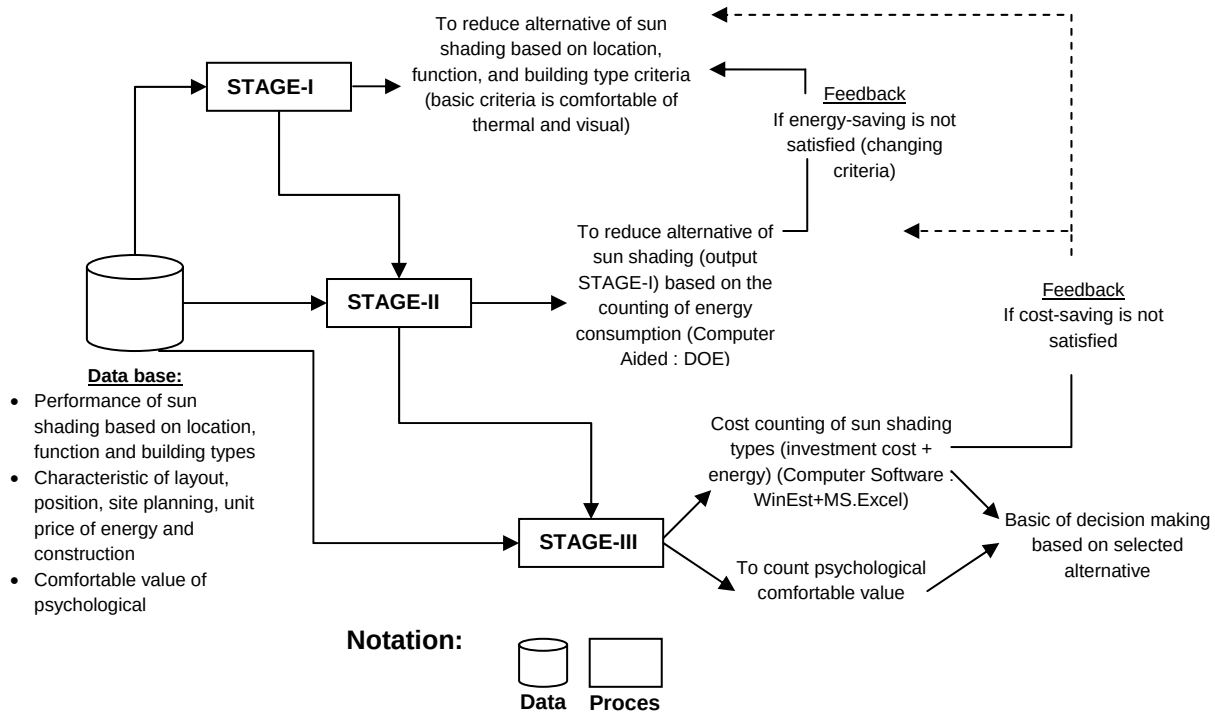


Diagram 2. Stages of sun shading design process at preliminary design.

Base on the process used in method which is developed above, we can conclude some points regarding the design as the following:

- Design that is conducted is *sun shading* design for multi-storey building in Jakarta that use **bioclimatic design concept.** That is why in the beginning stage of this design is to implement bioclimatic design concept base on design principles and bioclimatic design analysis i.e.: block plan, building orientation, etc. This approach must be implemented at the conceptual design stage and developed in schematic design.

- **Selection on alternative *sun shading* type,** base on **:** data base from the study of *sun shading* on multi-storey office building in Jakarta, design requirement criteria, building function, site location, and multi-storey building requirement. From numerous *sun shading* types that available, we select the alternative *sun shading* type*,* consider there are different requirement in certain location with certain function. Beside *sun shading* type*,* we also determine the *sun shading* position placement and material uses.

- Evaluation toward alternative choices is base on concept justification namely: comfortable and cost. Bioclimatic justification is used because the beginning concept of this design is bioclimatic design concept. Some of tools which are used to evaluate are DOE 2.I.E and building techno economic.

From few things that persistent with the design, it can be seen that the whole method that will be developed is in the **"bioclimatic"** frame. That is why the evaluation toward some alternative choices that have been chosen is base on bioclimatic design concept. Base on this concept there are three justifications in this evaluation i.e.:

1. Maximising user comfortable (as maximum as possible).
2. Minimizing the uses of energy/cost of energy (as minimum as possible)
3. Minimizing the uses of investment cost (as minimum as possible)

Generally, the stages of sun shading design method at preliminary design stage are as the following:

- The bioclimatic design concept is implemented in the beginning of design stage, and developed at the schematic design stage (such as building mass shape, mass orientation, dimension, etc base on literature study), which will become one of *sun shading* design *input* at the preliminary design stage.

- **Stage 1,** to reduce alternative *sun shading* from available types by using design criteria requirement. The criteria which are used as the main consideration are:
  1. **Sub stage 1-a,** building location (relate with climate that influence the building and easiness of implementation at location).
  2. **Sub stage 1-b,** building function (relate with building activity and typology, such as office, hotel, housing, etc.).
  3. **Sub stage 1-c,** building type (high, low or medium building).

  Alternative choices base on the available *sun shading* data base, in order to evaluate the performance that fit with criteria that has been determined.

- **Stage 2,** evaluation toward sun shading energy uses. Before this stage, the sun *shading* position placement at the building is determined (**sub stage 2-a**) base on *sun shading* alternative *input* which had chosen previous *(***stage 1** *input*). This evaluation that base on bioclimatic justification namely the uses of energy as minimum as possible can be done manually or using computer software, e.g. DOE.2.I.E (**sub stage 2-b**).

- **Stage 3,** determination of material uses and final evaluation toward alternative chosen, base on minimum cost justification and use maximum comfortable inside the building. This stage is divided into three sub stages as the following:
  1. **Sub stage 3-a** : applying material uses,
  2. **Sub stage 3-b** : cost calculation. (energy cost vs. construction cost), and
  3. **Sub stage 3-c** : calculation on psychological comfortable resulted

4. SUMMARY OF SUN SHADING DESIGN METHOD AT PRELIMINARY DESIGN STAGE

In order to observe the whole *sun shading* design method in a simple manner, the summary of the whole method is presented in tables that contain detail of each stage, including process and the input-output that is required in each process as the following:

STAGE-1			
STAGE	**INPUT**	**PROCESS**	**OUTPUT**
Stage 1-a	▪ Output from previous stage (schematic design) ▪ Data from condition of location ▪ Data base of sun shading types ▪ Criteria of sun shading based on location ▪ Performance of sun shading on site	▪ Decision for alternative of sun shading type-1	Alternatives-1 of sun shading type based on location
Stage 1-b	▪ Output from Stage 1-a ▪ Building function and code ▪ Criteria of sun shading based on function ▪ Performance of sun shading on building function	▪ Evaluate the chosen alternative based on criteria of the function requirement (office building, commercial building, etc)	Alternatives-2 of sun shading type based on location and function
Stage 1-c	▪ Output from Stage 1-b ▪ Condition of the building (multi storey) ▪ Criteria of sun shading based on building types ▪ Performance of sun shading on building types ▪ Implementation of sun shading on site	▪ Evaluate the chosen alternative based on criteria of building type requirement (multi storey bld/ sky scrapes, wide span, etc.)	Alternatives-3 of sun shading type based on location, function and building type requirement (multi storey bld/ sky scrapes)

To *STAGE-2*

STAGE-2			
STAGE	**INPUT**	**PROCESS**	**OUTPUT**
Stage 2-a	▪ Output from Stage 1-c ▪ Criteria of sun shading based on layout ▪ Previous data about site plan design (schematic design) ▪ Data of the need of shading area	▪ Decision for position of sun shading	▪ Alternatives-1 of sun shading at layout position
Stage 2-b	▪ Output from Stage 2-a ▪ Building code ▪ Output from schematic design : 1. Site plan data (altitude, azimuth, time-zone, humidity, building area, etc.) 2. Construction data per space zone (wall, floor, ceiling, roof, window) 3. Schedule of building usage (lighting, equipment usage, etc.) 4. Dimension (exterior envelope, window, floor, sun shading, etc.) 5. General condition of room (illumination level, maximum glare level permitted, temperature, lighting type, etc.) 6. Condition of service area 7. Description per room (based on zone)	▪ Evaluate the chosen alternative based on energy-saving, e.g. using DOE v2.1E	▪ Alternatives-2 of sun shading at layout position ▪ Total of Energy (KW, W/m^2) ▪ Dry and Wet temperature, total of sun radiation, wind speed, etc. ▪ Summary of room lighting load ▪ Summary of equipment load ▪ Summary of performance of building energy ▪ Electrical cost

STAGE-3			
STAGE	**INPUT**	**PROCESS**	**OUTPUT**
Stage 3-a	▪ Output from Stage 2-b ▪ Possibility data of implemented materials	Determining implementation of material	Alternative of using material
Stage 3-b	▪ Output from Stage 3-a ▪ Construction data (Construction cost) ▪ Data of electrical energy cost ▪ Building data	▪ Construction cost analysis of sun shading (using techno-economy) ▪ Computer aided : MS.Excel©, WinEst©, etc.	▪ Value of energy-cost saving ▪ Construction Cost of sun shading ▪ IRR (interest rate of return)
Stage 3-c	▪ Output from Stage 3-b ▪ Characteristic data of psychological comfortable ▪ Data of priority scale on site	Measuring of psychological comfortable value	Psychological comfortable value
Summary	Evaluation result within whole stages	Recommendation based on the counting result (on cost and energy)	Decision based on recommendation

5. SUGGESTIONS

Some suggestions that are recommended from this study are:

1. The method that is developed in this research is the early study. We expect that it can be followed up in further studies. We also recommend to develop this method as a decision making process of design in a computer program.

2. Some points that need further observation are:
   - A more complete data base arrangement with a better accuracy level in order to support the method which is developed.
   - A more accurate criteria formulation in order to get a better solution design.

- To simulate the method in a computer program, it is better to use the latest version and comprehensive program (such as DOE, Win Est, Excel, etc.).

3. It is better to use evaluation technique with a good evaluation method in order to observe subjective data evaluation which has not been developed.

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