Conceptual Design Support Tool for Offshore Platform Jacket Design

By

Muhamad Aliff Ashman bin Mohd Lokman

A project dissertation submitted to the

Mechanical Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfillment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(MECHANICAL ENGINEERING)

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TRONOH, PERAK

SEPTEMBER 2013

CERTIFICATION OF APPROVAL

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Approved by,

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A.P. Dr. Fakhruldin bin Mohd Hashim

UNIVERSITI TEKNOLOGI PETRONAS

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Muhamad Aliff Ashman bin Mohd Lokman

ABSTRACT

Conceptual design is the process by which the design is initiated, carried to the point of creating a number of possible solutions, and narrowed down to a single best concept. However, there are limited numbers of software that accommodates designer or engineers during this stage. Because of this, UTP developed a support tool called Conceptual Design Support Tool (CDST) to fill in the void. However, the available version of the CDST is currently developed to support subsea facilities and general mechanism designs. Therefore, in this project, the CDST was expanded to accommodate for the design of an offshore jacket which is also a static substructure that is yet to be embedded into CDST's database. The project started off with obtaining a datum design of a platform jacket and a functional decomposition of it was carried out. The decomposition was carried out with respect to the Handbook of Offshore Engineering (Chakrabarti, 2005) and also the technical standards provided by Det Norske Veritas (DNV). For each sub functions, three to five concept designs were identified and inserted into the CDST concept database. The next step was to generate a morphology chart for the sub functions and then generate possible concept variants from the morphology chart using CDST's concept generator feature. Once all the possible variants have been generated, sketches for each of the concept were reviewed and they were evaluated using CDST's Concept Evaluation Module. The ranked concepts were then reviewed whether they were realistic designs or not. Based on the functional decomposition carried out, three sub functions were identified and classified according to CDST's function and flow types. A total of 13 new concepts for the sub functions were identified and inserted into the database successfully.

ACKNOWLEDGEMENTS

I would like to acknowledge and extend my heartfelt gratitude to all those who have made it possible for me to complete this project. First and foremost, I would like thank my supervisor, A.P. Dr. Fakhruldin Mohd Hashim for his guidance and assistance throughout the course of this project. I would also like to thank Dr. Dereje Engida Woldemichael and A.P. Ir. Dr. Mohd Amin Abd. Majid for their feedbacks in this project. Not forgetting my parents, Mr. Mohd Lokman and Mdm. Salabiah for their endless support and encouragement throughout this project and my studies. Last but not least, I would also like to thank my friends and my fellow classmates for their assistance and support for me in completing this report.

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CHAPTER 1

INTRODUCTION

1.1 Background of Project

Conceptual design is an iterative process consisting of a series of generative and evaluative stages that gradually converge to a single preferred conceptual solution [1]. At each iteration, concepts are defined in increasing detail, thereby permitting ever more accurate evaluation. For example, a concept that starts off as a rough sketch may be developed through several iterations to possibly a scaled layout drawing and a mock-up. As the phase progresses, confidence in the ability of the concept or concepts to meet the Product Design Specifications (PDS) and eventually produce a valid solution will increase. The level of engineering detail applied to a concept before it is 'adopted' should be sufficient to permit accurate and realistic evaluation. As this process is often time-consuming, the tendency can be to 'cut and run', that is to adopt a concept without thorough evaluation [1]. This tendency should be resisted as it increases the probability of adopting a weak or flawed concept. The implications of this, in terms of increased cost and reduced product performance quality, will far outweigh the savings made in time and effort at the conceptual stage [1]. As a result of this concern, a support tool was developed to assists designers or engineers to help automate some of the tedious process involved in the process.

1.2 Problem Statement

The main intent of the CDST is to support designers or engineers in generating concept design(s) of an engineering system. However, the current version of the tool is limited to designing subsea facilities and mechanisms. Hence, the support tool will be expanded to support designing of offshore substructures since the industry lacks free software for such process.

1.3 Objective & Scope of Project

The objectives of this project are:

i. To expand and enhance the current version of CDST by enlarging the morphology chart library with offshore platform jacket due to lack of existing free software in the offshore engineering and construction field.
ii. To demonstrate the capability of the enhanced version of CDST by generating realistic designs.

The scope of this project will be:

i. Explore and familiarize with offshore platform jacket that will be integrated into CDST.
ii. Expand and improve the concept design variants for the offshore platform jacket leg.

CHAPTER 2

LITERATURE REVIEW

2.1 Conceptual Design Support Tool (CDST)

Conceptual Design Support Tool (CDST) is a new conceptual design process model in which the systematic design approach is integrated with knowledge-based system [2]. The nature of conceptual design process is iterative and time consuming. CDST is developed to assist designer during the conceptual design process by handling some of the monotonous activities giving the designer more time to concentrate on the creative part [3]. This tool will automate the process of generating alternative design concepts of a given design specifications, creating the morphology chart, combining suitable alternative concepts and evaluating concept variants.

Conventionally, conceptual design is done manually by designers as there were no computer tools developed for this process. This is probably due to the nature of the process whereby designers brainstorm suitable concepts based on his/her available knowledge to avoid problems. However, this traditional method is time consuming and will eventually cost money. CDST however will cut down the time and money spent on the conceptual design stage and directly allows the designer to spend more time on other stages or process.

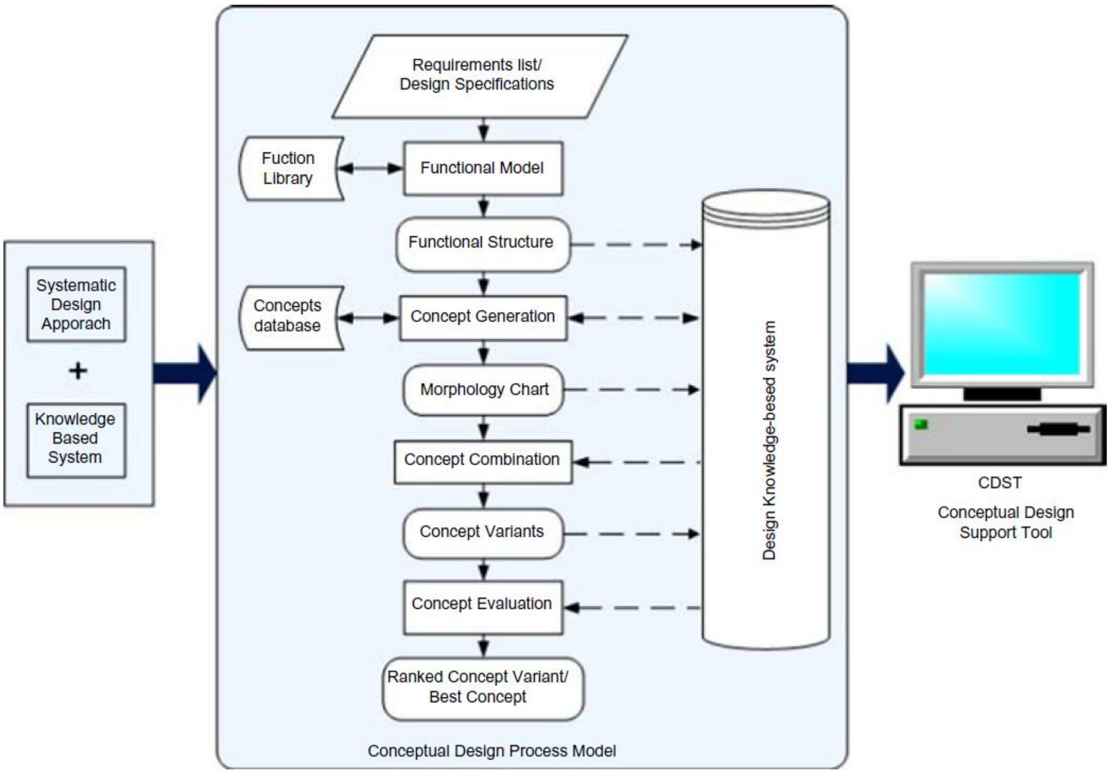


FIGURE 1: The proposed CDST Process Model [3]

Through a thorough research, the process model for CDST was proposed in which the model incorporates the Systematic Design Approach system with the Knowledge-Based system. The processes are carried out by using the designer's knowledge and/or the Design Knowledge-Based system's and the achievements from a given process are then displayed to the user such as shown in Figure 1. The achievements are also defined as an input to the Design Knowledge-Based system database and will be used again in the future. The CDST is currently the only computer support tool that addresses the design of any products. Although the tool is still developing in order to support more products, it is still able to assist designers or engineers in creating preferred solutions for their design. This support tool will be used extensively in this project to further enhance its database to cater the public and the industry.

2.2 Morphology Chart

Morphological analysis is a method for representing and exploring all the relationships in multidimensional problems. The process was developed into a technique for generating design solutions by Fritz Zwicky in the 1960s [4]. Zwicky concluded that morphological analysis is very effective for solution synthesis when paired with functional decomposition [5]. The general morphological approach to design is summarized in the following three steps:

i. Divide the overall design problem into simpler sub-problems.
ii. Generate solution concepts for each sub-problem.
iii. Systematically combine sub-problem solutions into different complete solutions and evaluate all combinations.

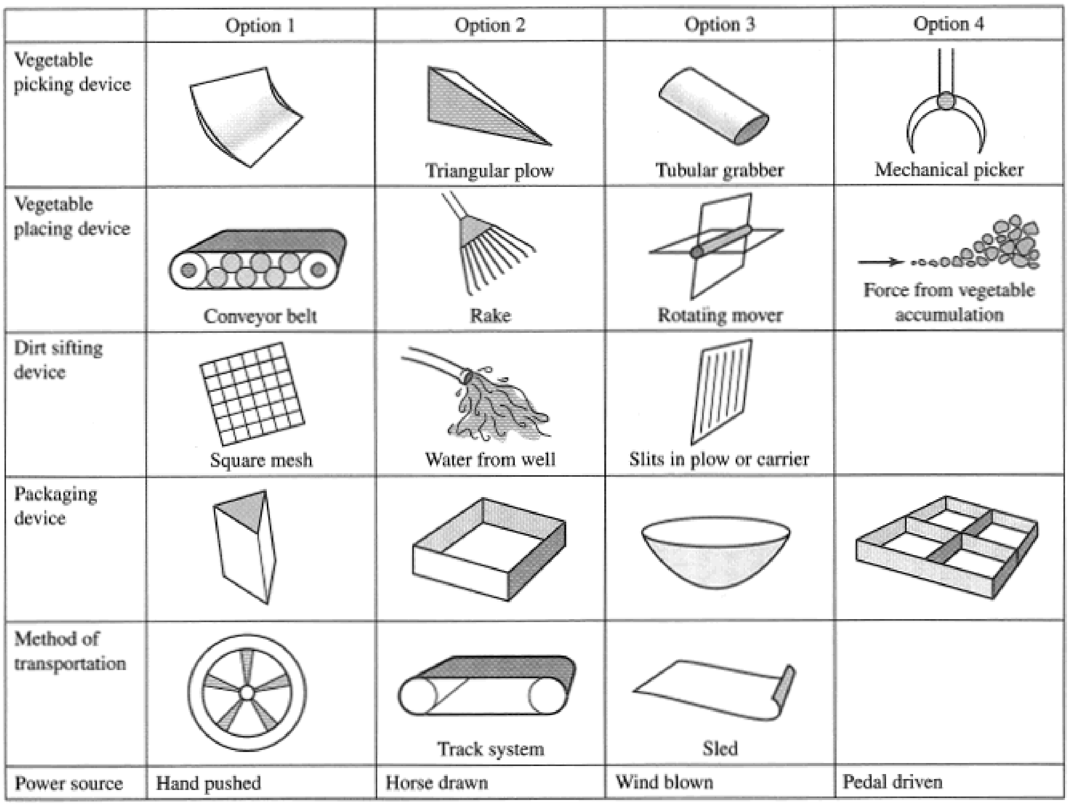


FIGURE 2: An example of a Morphological Chart [6]

Firstly, a table is constructed by listing all the sub-problems in a column. The possible solutions to each sub-problem are then listed down visually in rows next to the column as such in Figure 2. The feasible solutions can then be selected from every sub-problem and a concept will be generated. Depending on the number of options provided for each sub-problem, the number of possible concepts generated can be large. Therefore it is up to the designer to limit the number of options according to its attractiveness.

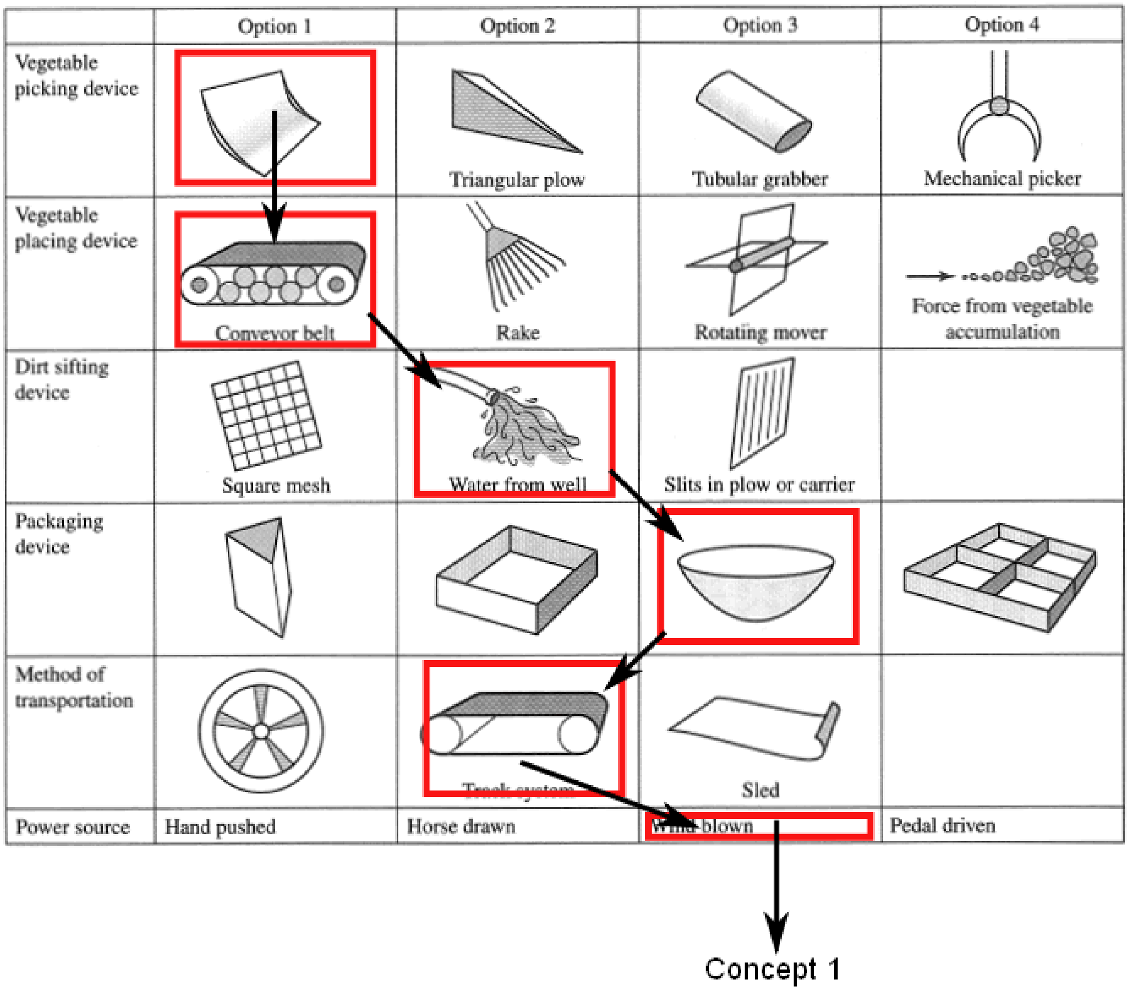


FIGURE 3: A concept generated from the Morphological Chart [6]

With CDST, the process of generating the morphological chart will consume less time as the solution options are available in the tool's database. New options that are not readily available can be inserted into the system by the designer and thus expanding the system's database and providing more concept variants.

2.3 Platform Jacket

The function of an offshore platform is to allow drilling and production activities to be carried on using conventional above-water procedures [7]. However, there are many types of offshore platform available and each serves for different types of geography. The most common type of offshore platform is the Fixed Steel Jacket Platform and Figure 3 shows a 3-dimensional (3D) model of a steel jacket. Since the beginnings in 1947, approximately 10,000 offshore structures have been constructed and a majority of these structures are of the fixed steel jacket platform [8].

FIGURE 4: A 3D model of a steel jacket [9]

An offshore platform has the same general requirements as any other industrial structure. It must fulfill its intended purpose; it must be structurally adequate for both operational and environmental loading; it must be practical to construct, and it must be cost-effective [8]. The design of an offshore platform involves consideration of all of these factors. An offshore platform is not designed for aesthetic or architectural considerations. The overall concept is influenced as much by methods of fabrication and installation as it is by the applied operational and environmental loadings [10].

As the cost of fabricating and installing an offshore platform is very high, designing a platform that does not require change orders during the detailed design or fabrication process will be very important. With the help of CDST during the conceptual design stage, this target can be achieved by the industry with satisfying results.

CHAPTER 3

METHODOLOGY

3.1 Project Flow Chart

This section will discuss about the project flow in order to complete the project on Conceptual Design Support Tool for Offshore Platform Jacket. After the title selection process has been completed, preliminary research work on the title are done including consulting the project supervisor. The background information and problem statement of the title given by the supervisor were studied extensively in order to grasp the objective and nature of the project.

After the initial study has been done, extensive literature review is then carried out. This includes retrieving and reviewing journals, technical papers and handbooks related to the topic in order to obtain a clearer and thorough understanding of it. Literature reviews are done according to keywords found in the title itself such as “Conceptual Design” and “offshore platform jacket”.

The next step of the project will be to familiarize with the functionality and usage of the support tool itself. This section is done in the Function library Window of the CDST. Next is to choose the required functional class of the equipments that corresponding to the sub-functions. Next is to choose the primary flow in which will be corresponding with the “Noun”, “Input Flow”, and “Output Flow” choices in the secondary and tertiary flows. After all the required information is properly selected, the sub-functions are saved into the working memory. The sub-functions are now available to the software for the next stage. The next step is to generate the Morphology charts of the sub-functions selected. The morphology chart will display all the available concepts that correspond to the sub-functions selected. This is then followed by understanding the back-end process of the tool which includes on how to expand the system’s database and creating new concept variants.

In order to enhance the CDST’s concept database, a thorough study on the design of offshore platform jackets must be done. A datum must also be identified from existing design or product. It is important as understanding on the design and working principles of the jacket is needed to execute functional decomposition of the product. This decomposition will then be used to create a morphological analysis of the functions and physical properties that the jacket has. The functions will then be classified according to industrial technical standards or engineering handbooks to ensure that design generated will be accepted. The design functions will be embedded into CDST's system once they have been classified. After that, a morphology chart will be generated to ensure that the sub functions are valid. If a morphology chart cannot be generated, the corrected sub functions will be reinserted into the database. After a valid morphology chart has been generated, the concept variants will be generated using the software. The software will list out all the possible combinations from the morphology chart. If the concept variants cannot be generated, the morphology chart should be regenerated. From the generated concept variants, sketches of each of the concept can be produced. If the sketches are found to be realistic, their ranking will be evaluated using methods available in CDST. If the sketches are not realistic, the morphology chart should be regenerated.

Once the enhancement stage has been completed, the new CDST will be put to the test against the old version to demonstrate its new capabilities to produce realistic conceptual designs of a platform jacket. The project will end with discussing and analyzing the results obtained which will then be included in the final report.

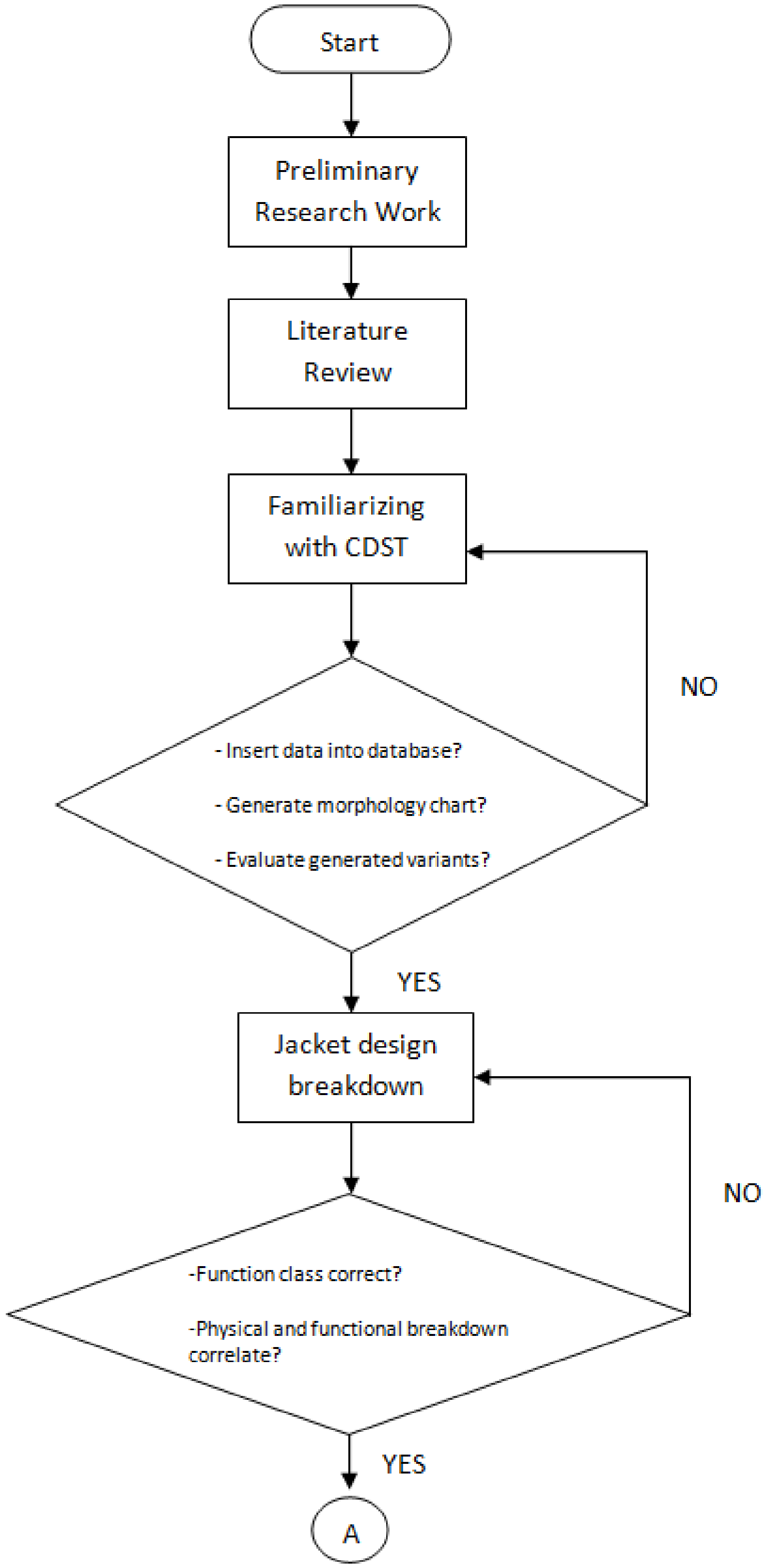


FIGURE 5: Proposed project flow chart

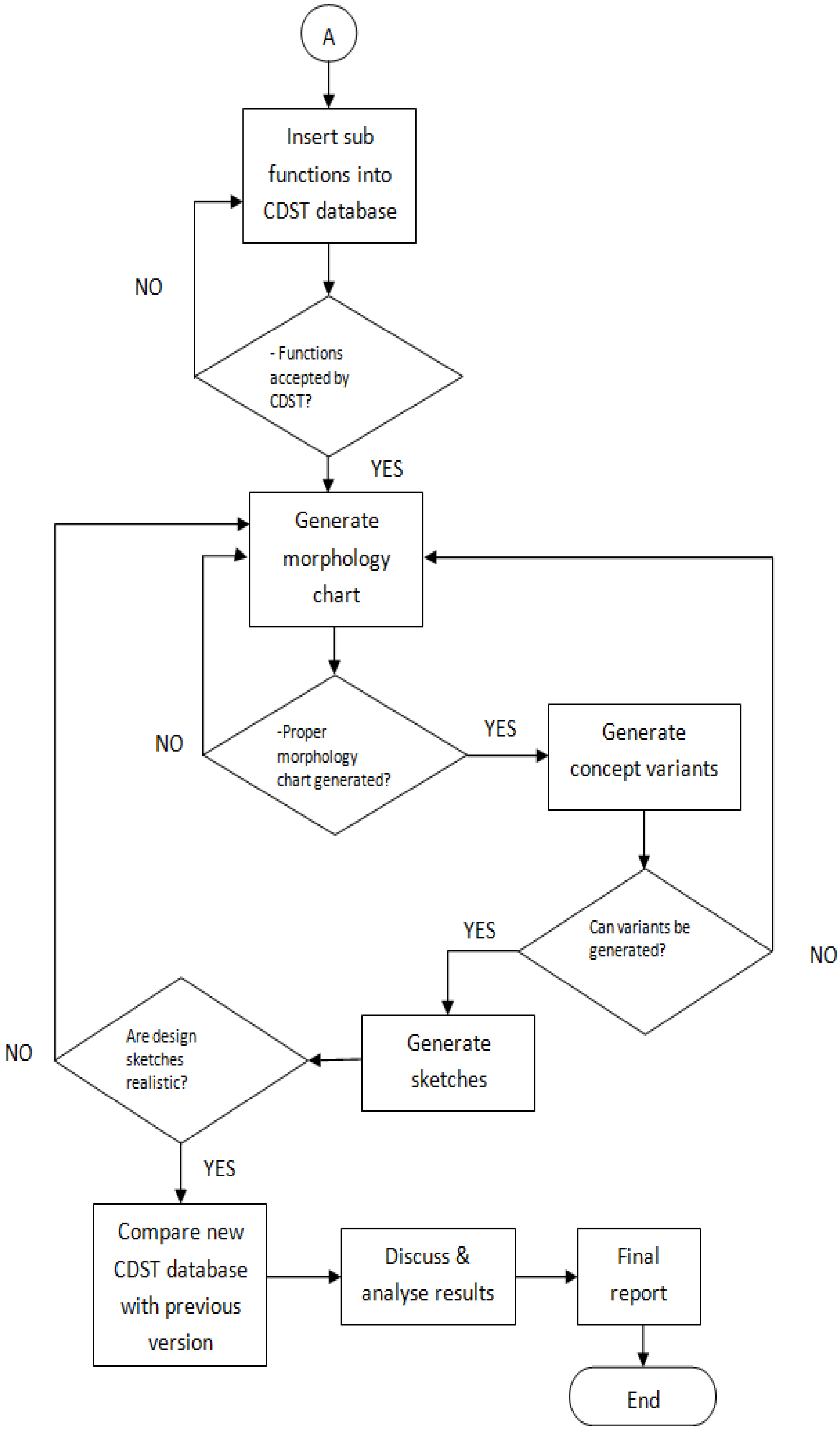


FIGURE 5: Proposed project flow chart (cont'd)

3.2 Project Gantt chart

Below are the Gantt charts for this project. The project was conducted in two semesters as per requirement of the course.

Task	Final Year Semester 1													
	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Selection of project title														
2. Preliminary research work • **Literature review**														
3. Familiarization of CDST														
4. Research on platform jacket • Jacket design breakdown • **Understand functions**														
5. Submission of interim report														

FIGURE 6: Project Gantt chart for FYP 1

Task	Final Year Semester 2													
	Week													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
6. Expanding CDST database concept • Generate new concept • **Embed new concept**														
7. Submission of progress report														
8. CDST Demonstration • Morphology chart • **Realistic design generated**														
9. Submission of dissertation														
10. Oral presentation														
11. Submission of final report														

FIGURE 7: Project Gantt chart for FYP 2

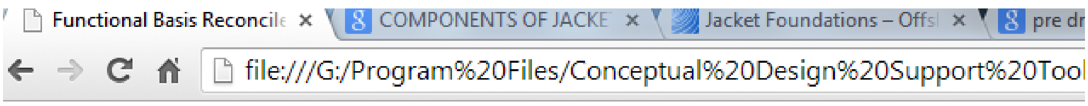
Milestones

CHAPTER 4

DATA GATHERING & ANALYSIS

4.1 Familiarizing with CDST

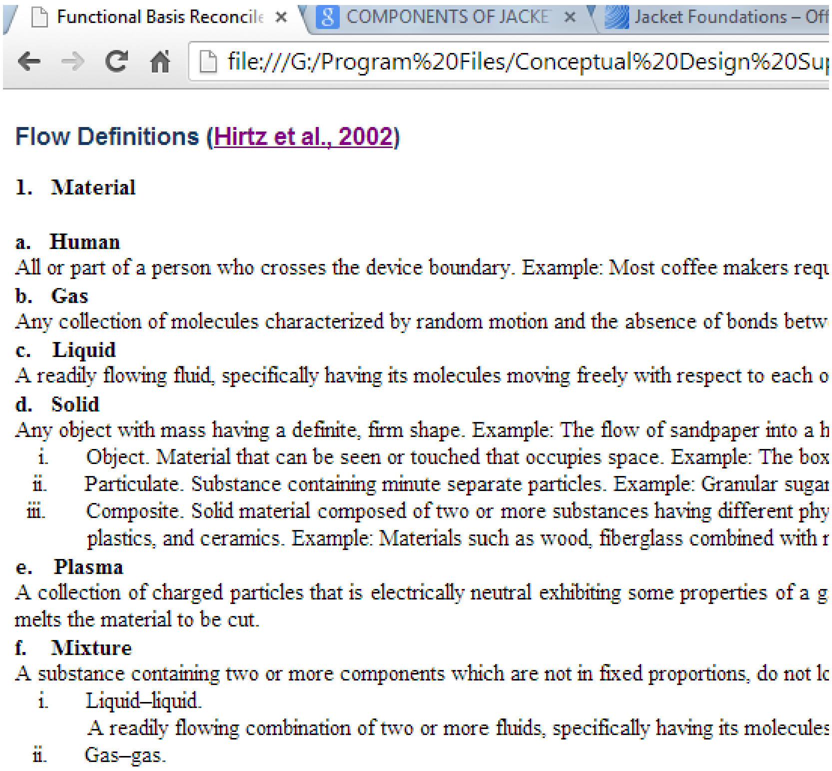
Navigating the CDST software was relatively easy. The "Help" files were very helpful as the software developer provided a thorough guide on how to use the software. The files also contained the definitions of every functions and flows available in the software. Figures 8 and 9 show some of the definitions for the available functions and flows such as Support, Connect, Material and Energy [11].



Flow Classification (Hirtz et al., 2002)

Class (Primary)	Secondary	Tertiary	Correspondents
Material	Human		Hand, foot, head
	Gas		Homogeneous
	Liquid		Incompressible, compressible, homogeneous
	Solid	Object	Rigid-body, elastic-body, widget
		Particulate	
		Composite	
	Plasma		
	Mixture	Gas–gas	
		Liquid–liquid	Aggregate
		Solid–solid	
		Solid–liquid	
		Liquid–gas	
		Solid–gas	
		Solid–liquid–gas	
		Colloidal	Aerosol
Signal	Status	Auditory	Tone, word
		Olfactory	
		Tactile	Temperature, pressure, roughness
		Taste	
		Visual	Position, displacement
	Control	Analog	Oscillatory
		Discrete	Binary
Energy	Human		
	Acoustic		
	Biological		

FIGURE 8: Definition of types of Functions


Functional Basis Reconcile × COMPONENTS OF JACKE × Jacket Foundations – Off

file:///G:/Program%20Files/Conceptual%20Design%20Su

Flow Definitions (Hirtz et al., 2002)

1. **Material**

a. **Human**
All or part of a person who crosses the device boundary. Example: Most coffee makers requ
b. **Gas**
Any collection of molecules characterized by random motion and the absence of bonds betw
c. **Liquid**
A readily flowing fluid, specifically having its molecules moving freely with respect to each o
d. **Solid**
Any object with mass having a definite, firm shape. Example: The flow of sandpaper into a h
i. Object. Material that can be seen or touched that occupies space. Example: The box
ii. Particulate. Substance containing minute separate particles. Example: Granular sugar
iii. Composite. Solid material composed of two or more substances having different phy plastics, and ceramics. Example: Materials such as wood, fiberglass combined with r
e. **Plasma**
A collection of charged particles that is electrically neutral exhibiting some properties of a g melts the material to be cut.
f. **Mixture**
A substance containing two or more components which are not in fixed proportions, do not lo
i. Liquid–liquid.
A readily flowing combination of two or more fluids, specifically having its molecules
ii. Gas–gas.

FIGURE 9: Definitions of types of Flow

Getting familiar with the available functions and flows is important as the software's knowledge database is based on these set of information. When a new concept needs to be added into the database, the software wizard will ask for the type of function and flow that each of the alternative possess as such shown in Figure 10.

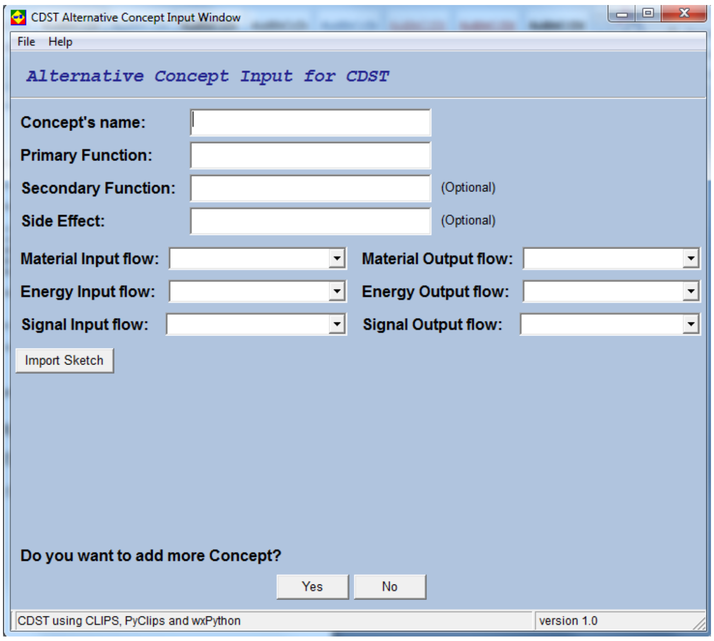


FIGURE 10: Alternative Concept Input wizard [11]

After all the alternative concepts have been stored into the database, the user can then start using the software by selecting the main type of function and flow of one part of the item to be designed by inputting the keyword into the wizard. The user will then select the available sub-function and sub-flow in the "Function Name" section such as show in Figure 11.

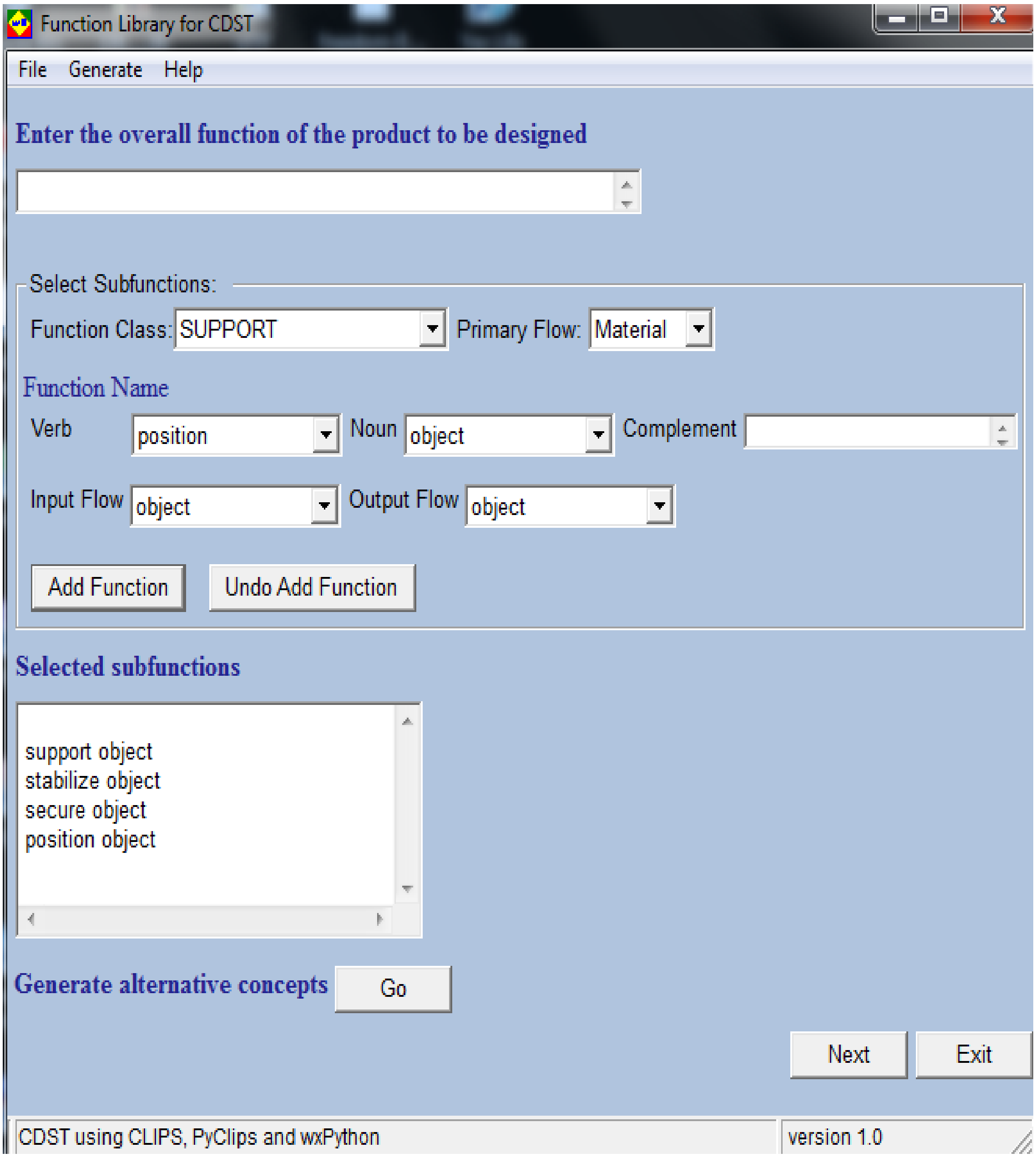


FIGURE 11: Function Selection wizard

After adding their desired sub-functions, the software will then generate a morphology chart based on those sub-functions such as shown in Figure 12.

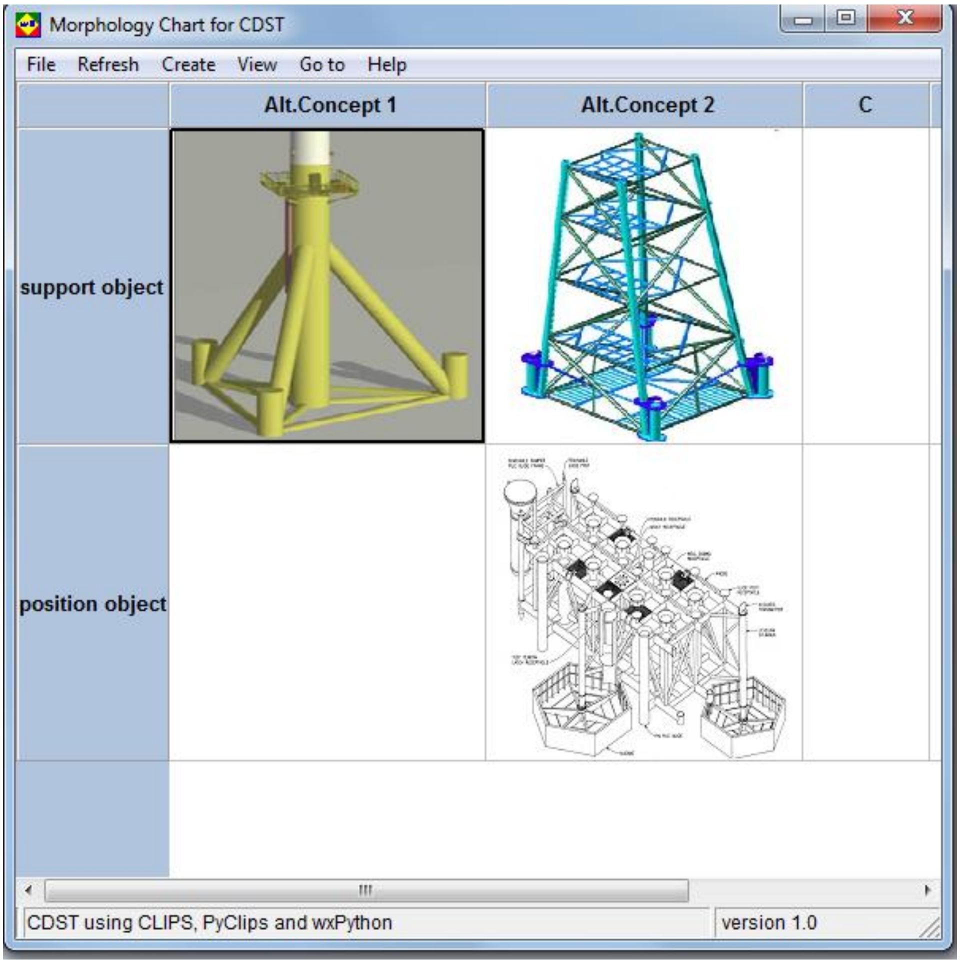


FIGURE 12: Example of morphology chart generated

The user can then proceed by creating the concept variants which will then list out all the possible combinations. Next the software will generate the sketches for each of the variant such as shown in Figure 13.

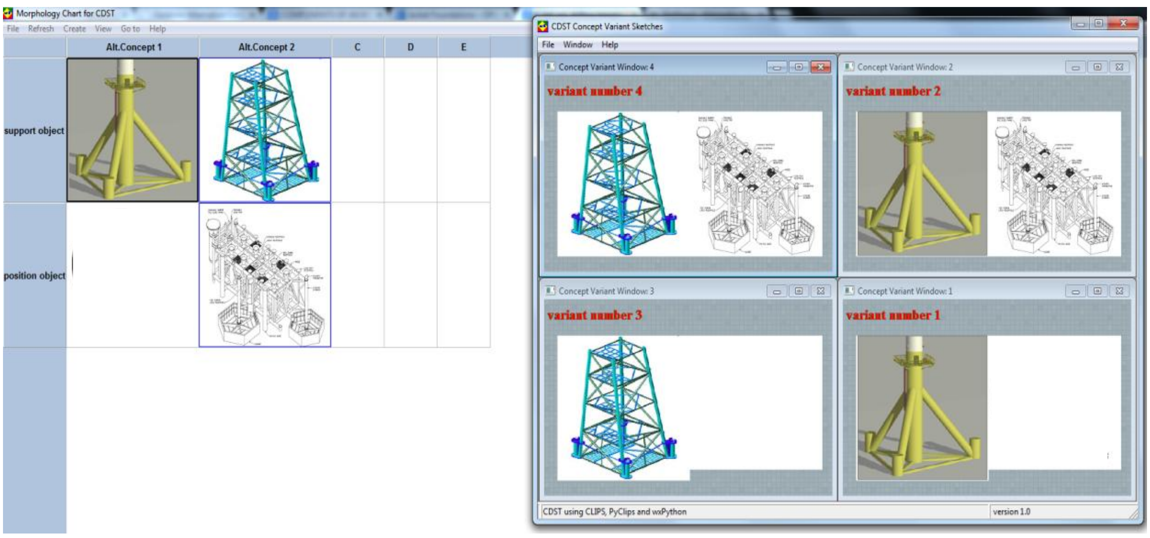


FIGURE 13: Sketches of each concept variant

The next step will be evaluating each of the concepts and for that CDST has 3 methods available such as shown in Figure 14. The user will be able to define their set of evaluation criteria apart from the available criteria in the software.

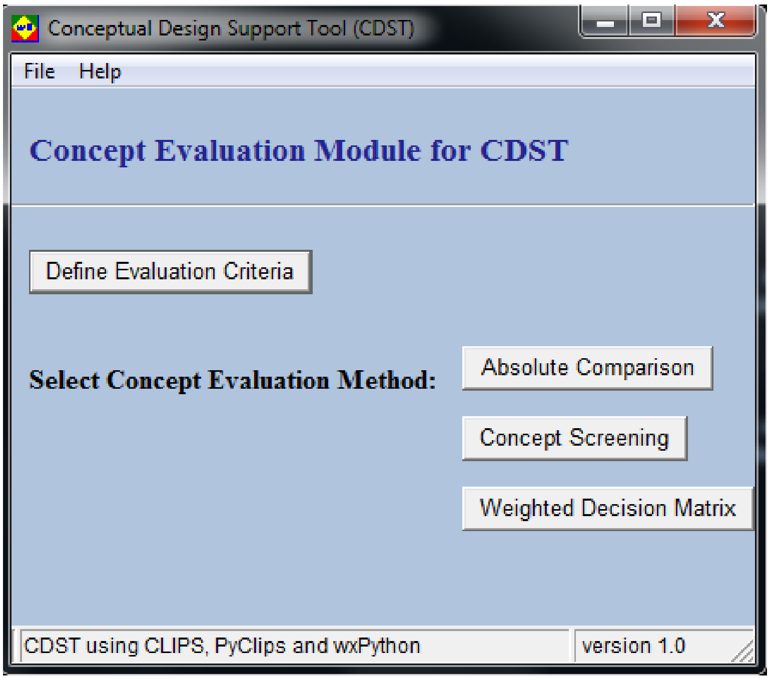
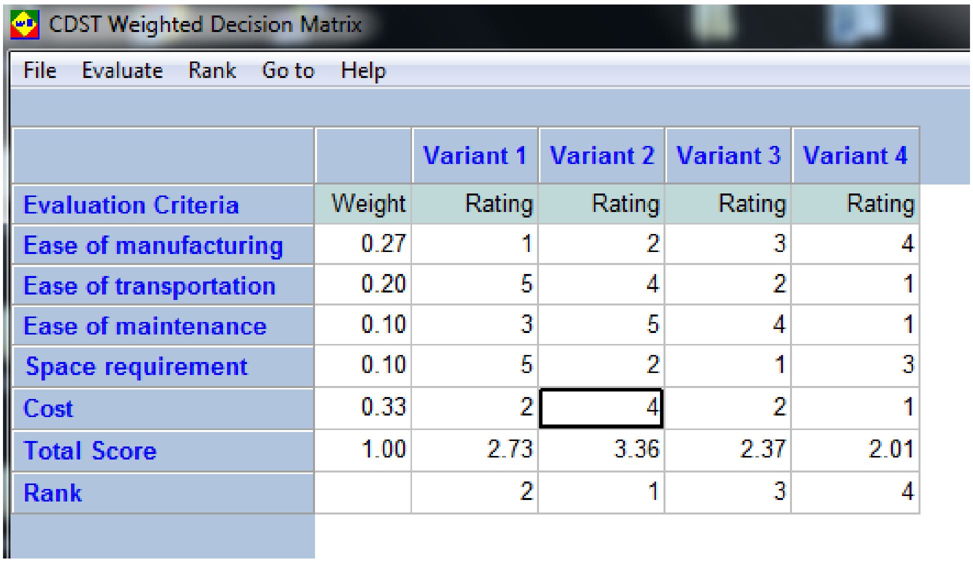


FIGURE 14: Evaluation methods available

Finally, the user will need to evaluate the each of the concepts based on the pre-determined criteria. The software will help rank the concepts based on the result of the evaluation step such as shown in Figure 15.



		Variant 1	Variant 2	Variant 3	Variant 4
Evaluation Criteria	Weight	Rating	Rating	Rating	Rating
Ease of manufacturing	0.27	1	2	3	4
Ease of transportation	0.20	5	4	2	1
Ease of maintenance	0.10	3	5	4	1
Space requirement	0.10	5	2	1	3
Cost	0.33	2	4	2	1
Total Score	1.00	2.73	3.36	2.37	2.01
Rank		2	1	3	4

FIGURE 15: Evaluated and ranked concept variants

4.2 Design Breakdown of Jacket

The functional breakdown of a jacket was based on Figure 16 shown below.

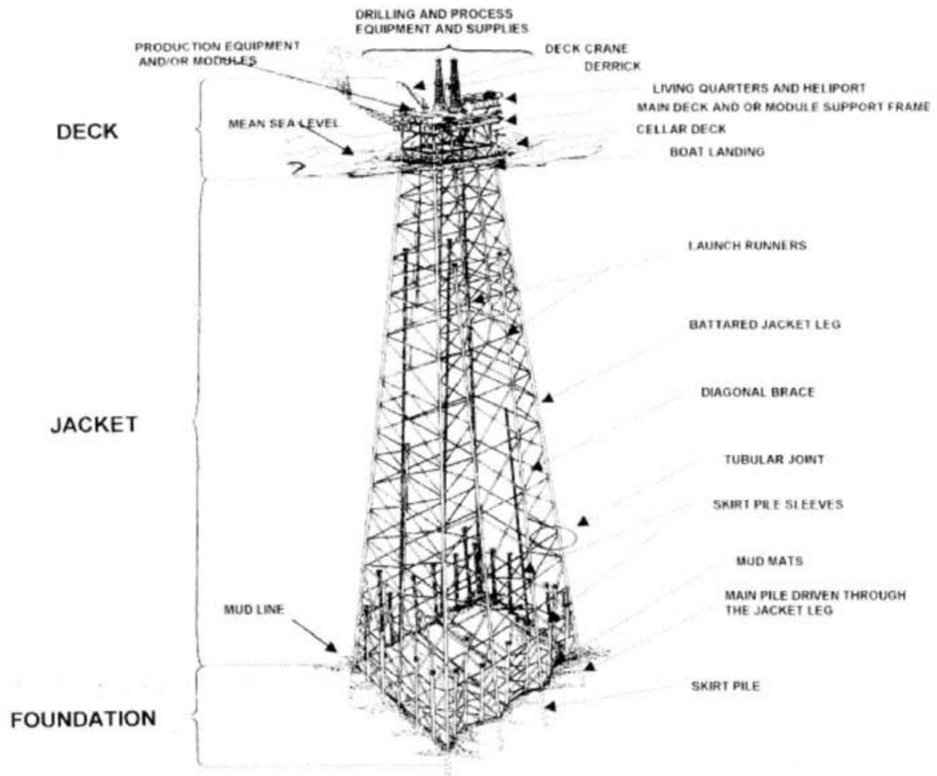


FIGURE 16: Main elements of steel jacket platform [12]

The figure shows the main elements present in a steel jacket platform which are the deck, jacket and foundation. The decomposition will focus on the jacket only which is a substructure of the platform such as shown in Figure 17 below.

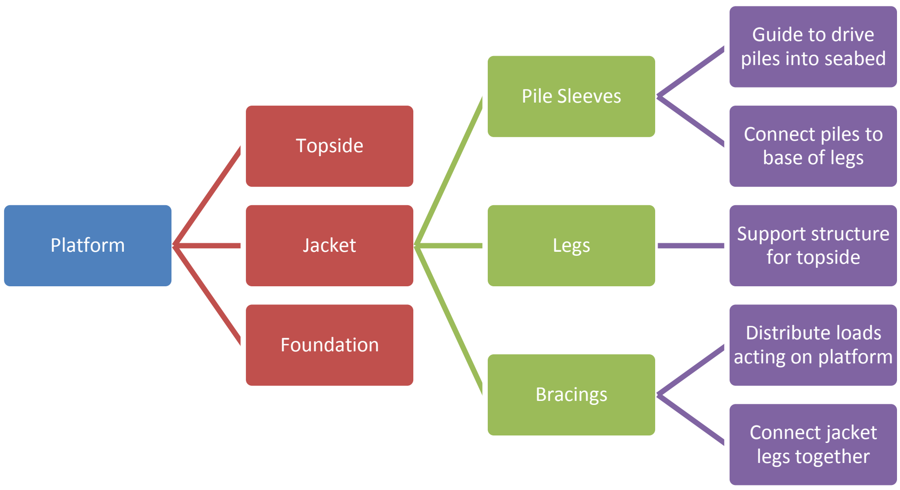


FIGURE 17: Functional decomposition of jacket

4.2.1 Piling Sleeves

Table 1: Classification for Piling Slots

	Function	Flow
Class	Support	Material
Primary	Position	Object
Secondary	Connect	Object

Primary physical function: Guide for driving in piles into seabed & connecting base of jacket to pile heads.

Pile sleeves are circular slots welded on to the base of the jacket legs. The purpose of pile sleeves is to guide the pile into its designated location when driving it into the seabed. It is also the connecting piece between the piles and the jacket [12]. Figure 18 shows an example of jacket pile sleeve.

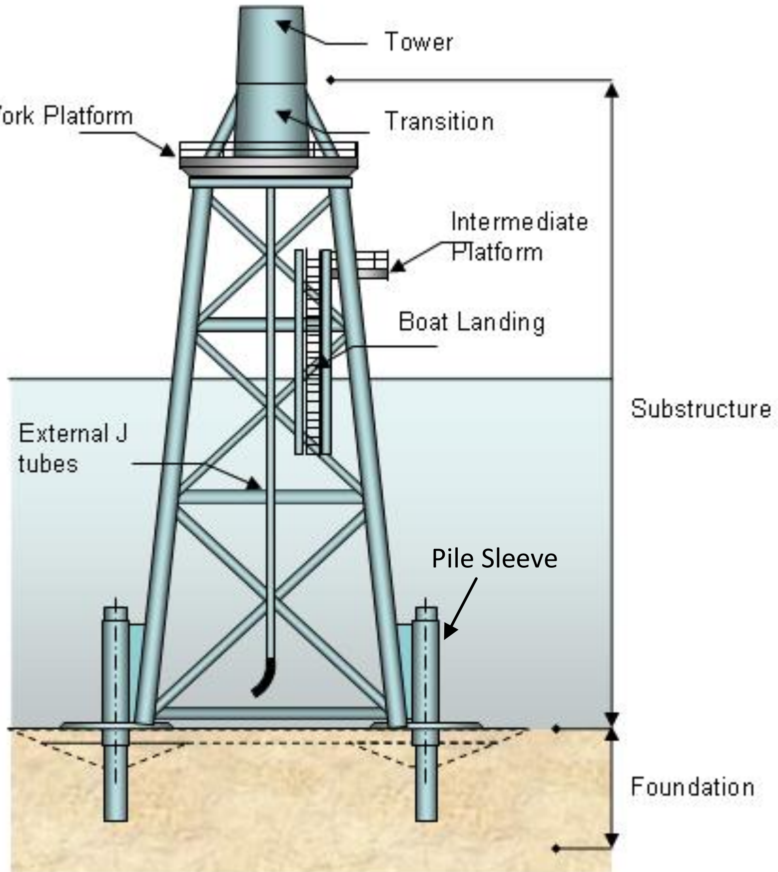


FIGURE 18: Jacket pile sleeve [13]

4.2.2 Legs

Table 2: Classification for Legs

	Function	Flow
Class	Support	Object
Primary	Support	Object

Primary physical function: Serves as support for topside (deck) [12]

The legs of a jacket are the braced tubular structure of the jacket. Generally it serves two functions:

- They provide the substructure for the production facility (topside), keeping it stable above the waves.
- They support laterally and protect the well conductors and the pipeline riser [14].

The number of legs in a jacket depends on the number of pre-drilled well and also the size and function of the topside. The common numbers of legs for a jacket are 1, 3, 4, 6 and 8 such as show in Figure 18.

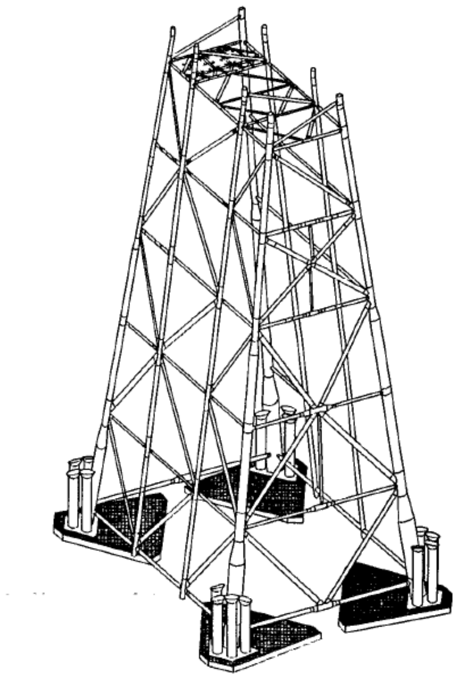


FIGURE 19: An 8-legged jacket [15]

4.2.3 Bracings

Table 3: Classifications for Bracings

	Function	Flow
Class	Branch	Energy
Primary	Distribute	Mechanical energy
Secondary	Connect	Object

Primary physical function: Distribute loads acting on jacket legs.

Bracings are the tubular structure that connects and hold the legs in place. They are welded together with the legs to produce tubular joints such as shown in Figure 19. Bracing reduces the need for internal support columns thus creating more floor space for the conductors and risers.

FIGURE 20: A jacket leg with bracings [16]

CHAPTER 5

RESULTS & DISCUSSION

There were 13 new concepts that were inserted into the software's database and they were classified into three sub functions based on the software's function and flow classification system. The three sub functions are "Support Object", "Position Object" and "Distribute Mechanical Energy". These functions were identified after the decomposition process was performed. The next step was to recall the functions in order to generate a morphology chart for the product. This step can be easily done by using the software's Function Library wizard such as shown in Figure 21 below.

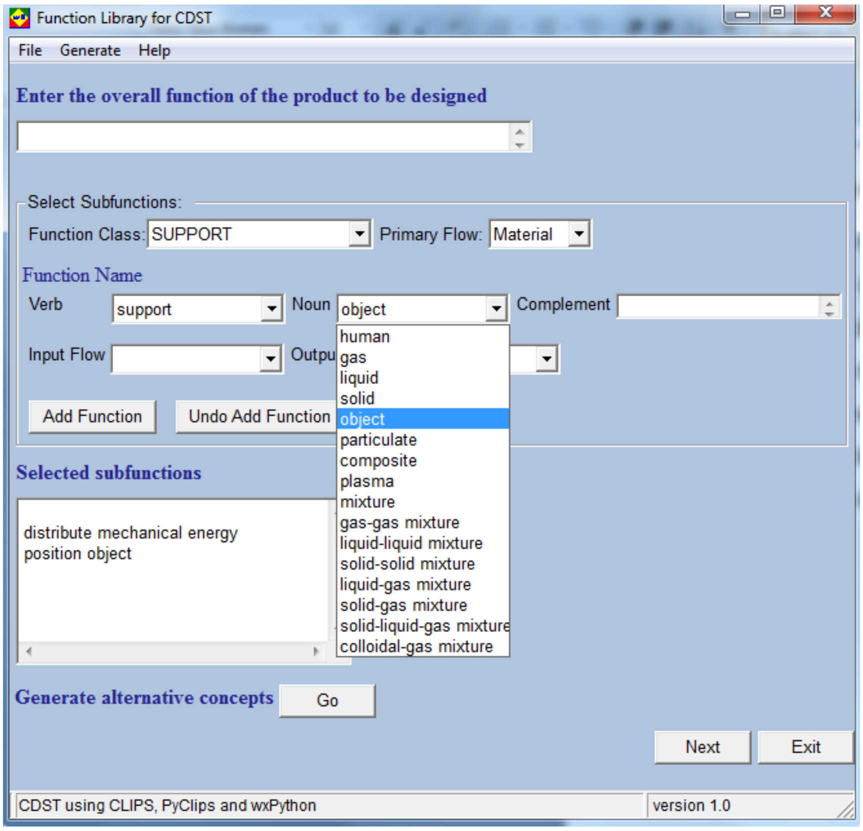


FIGURE 21: Function Library wizard to recall sub functions

Once the morphology chart has been generated such as shown in Figure 22, any undesired concepts that are unrelated to product design were removed. Next, the concept variants were generated to combine all the alternative concepts.

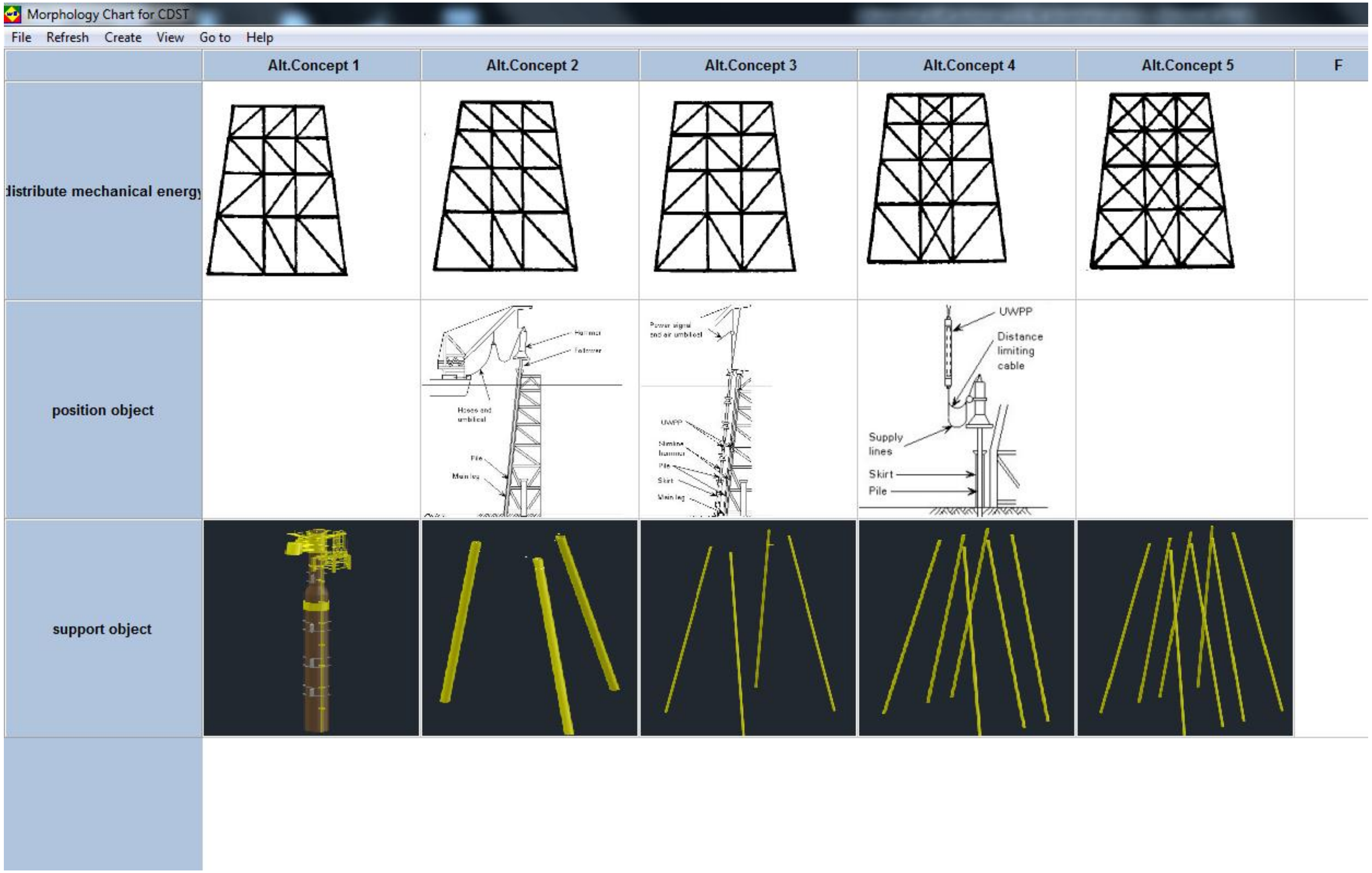


FIGURE 22: Generated morphology chart

Based on the 13 new concepts inserted, 75 alternative concept designs were generated, as shown in Figure 23 below.

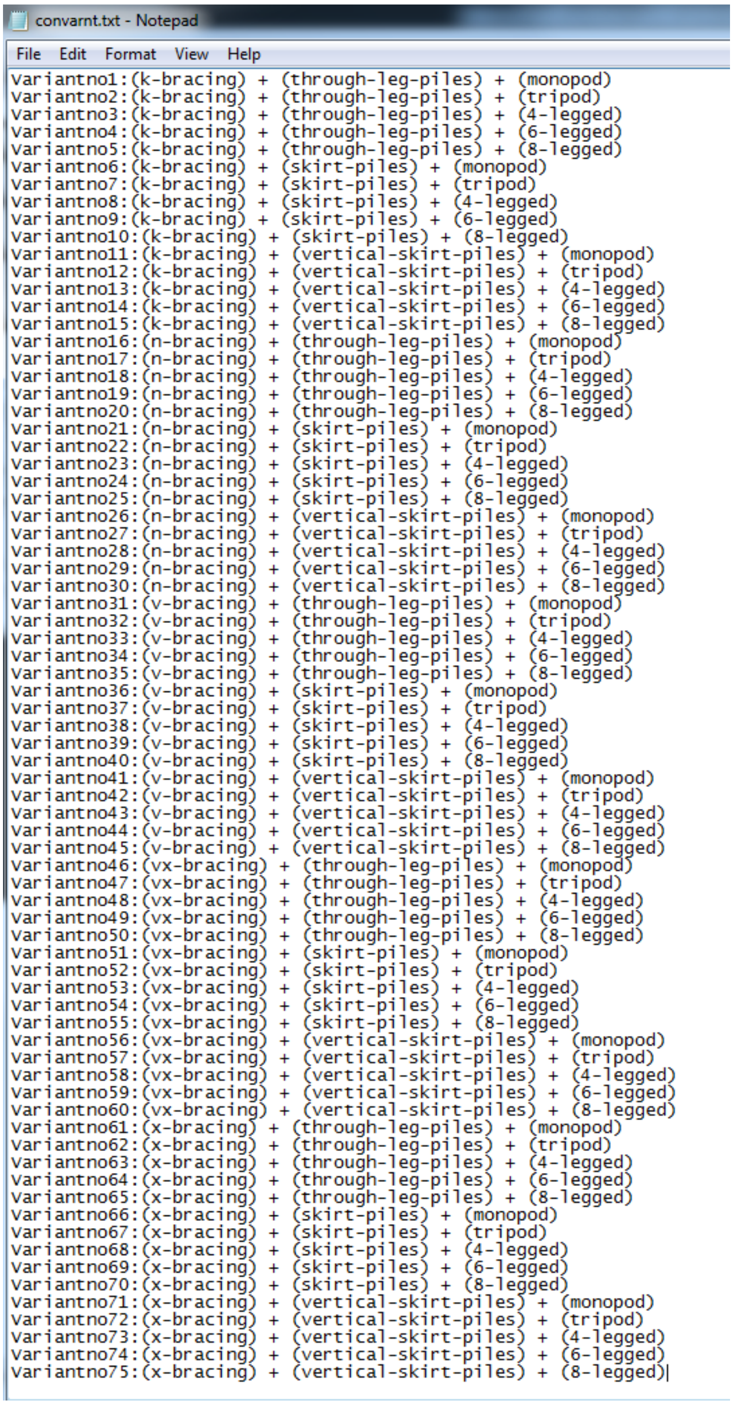

convarnt.txt - Notepad
File Edit Format View Help
```
variantno1:(k-bracing) + (through-leg-piles) + (monopod)
variantno2:(k-bracing) + (through-leg-piles) + (tripod)
variantno3:(k-bracing) + (through-leg-piles) + (4-legged)
variantno4:(k-bracing) + (through-leg-piles) + (6-legged)
variantno5:(k-bracing) + (through-leg-piles) + (8-legged)
variantno6:(k-bracing) + (skirt-piles) + (monopod)
variantno7:(k-bracing) + (skirt-piles) + (tripod)
variantno8:(k-bracing) + (skirt-piles) + (4-legged)
variantno9:(k-bracing) + (skirt-piles) + (6-legged)
variantno10:(k-bracing) + (skirt-piles) + (8-legged)
variantno11:(k-bracing) + (vertical-skirt-piles) + (monopod)
variantno12:(k-bracing) + (vertical-skirt-piles) + (tripod)
variantno13:(k-bracing) + (vertical-skirt-piles) + (4-legged)
variantno14:(k-bracing) + (vertical-skirt-piles) + (6-legged)
variantno15:(k-bracing) + (vertical-skirt-piles) + (8-legged)
variantno16:(n-bracing) + (through-leg-piles) + (monopod)
variantno17:(n-bracing) + (through-leg-piles) + (tripod)
variantno18:(n-bracing) + (through-leg-piles) + (4-legged)
variantno19:(n-bracing) + (through-leg-piles) + (6-legged)
variantno20:(n-bracing) + (through-leg-piles) + (8-legged)
variantno21:(n-bracing) + (skirt-piles) + (monopod)
variantno22:(n-bracing) + (skirt-piles) + (tripod)
variantno23:(n-bracing) + (skirt-piles) + (4-legged)
variantno24:(n-bracing) + (skirt-piles) + (6-legged)
variantno25:(n-bracing) + (skirt-piles) + (8-legged)
variantno26:(n-bracing) + (vertical-skirt-piles) + (monopod)
variantno27:(n-bracing) + (vertical-skirt-piles) + (tripod)
variantno28:(n-bracing) + (vertical-skirt-piles) + (4-legged)
variantno29:(n-bracing) + (vertical-skirt-piles) + (6-legged)
variantno30:(n-bracing) + (vertical-skirt-piles) + (8-legged)
variantno31:(v-bracing) + (through-leg-piles) + (monopod)
variantno32:(v-bracing) + (through-leg-piles) + (tripod)
variantno33:(v-bracing) + (through-leg-piles) + (4-legged)
variantno34:(v-bracing) + (through-leg-piles) + (6-legged)
variantno35:(v-bracing) + (through-leg-piles) + (8-legged)
variantno36:(v-bracing) + (skirt-piles) + (monopod)
variantno37:(v-bracing) + (skirt-piles) + (tripod)
variantno38:(v-bracing) + (skirt-piles) + (4-legged)
variantno39:(v-bracing) + (skirt-piles) + (6-legged)
variantno40:(v-bracing) + (skirt-piles) + (8-legged)
variantno41:(v-bracing) + (vertical-skirt-piles) + (monopod)
variantno42:(v-bracing) + (vertical-skirt-piles) + (tripod)
variantno43:(v-bracing) + (vertical-skirt-piles) + (4-legged)
variantno44:(v-bracing) + (vertical-skirt-piles) + (6-legged)
variantno45:(v-bracing) + (vertical-skirt-piles) + (8-legged)
variantno46:(vx-bracing) + (through-leg-piles) + (monopod)
variantno47:(vx-bracing) + (through-leg-piles) + (tripod)
variantno48:(vx-bracing) + (through-leg-piles) + (4-legged)
variantno49:(vx-bracing) + (through-leg-piles) + (6-legged)
variantno50:(vx-bracing) + (through-leg-piles) + (8-legged)
variantno51:(vx-bracing) + (skirt-piles) + (monopod)
variantno52:(vx-bracing) + (skirt-piles) + (tripod)
variantno53:(vx-bracing) + (skirt-piles) + (4-legged)
variantno54:(vx-bracing) + (skirt-piles) + (6-legged)
variantno55:(vx-bracing) + (skirt-piles) + (8-legged)
variantno56:(vx-bracing) + (vertical-skirt-piles) + (monopod)
variantno57:(vx-bracing) + (vertical-skirt-piles) + (tripod)
variantno58:(vx-bracing) + (vertical-skirt-piles) + (4-legged)
variantno59:(vx-bracing) + (vertical-skirt-piles) + (6-legged)
variantno60:(vx-bracing) + (vertical-skirt-piles) + (8-legged)
variantno61:(x-bracing) + (through-leg-piles) + (monopod)
variantno62:(x-bracing) + (through-leg-piles) + (tripod)
variantno63:(x-bracing) + (through-leg-piles) + (4-legged)
variantno64:(x-bracing) + (through-leg-piles) + (6-legged)
variantno65:(x-bracing) + (through-leg-piles) + (8-legged)
variantno66:(x-bracing) + (skirt-piles) + (monopod)
variantno67:(x-bracing) + (skirt-piles) + (tripod)
variantno68:(x-bracing) + (skirt-piles) + (4-legged)
variantno69:(x-bracing) + (skirt-piles) + (6-legged)
variantno70:(x-bracing) + (skirt-piles) + (8-legged)
variantno71:(x-bracing) + (vertical-skirt-piles) + (monopod)
variantno72:(x-bracing) + (vertical-skirt-piles) + (tripod)
variantno73:(x-bracing) + (vertical-skirt-piles) + (4-legged)
variantno74:(x-bracing) + (vertical-skirt-piles) + (6-legged)
variantno75:(x-bracing) + (vertical-skirt-piles) + (8-legged)
```

FIGURE 23: 75 concept variants from morphology chart

After the concept variants have been generated, the sketches for every variants can be viewed such as shown in Figure 24.

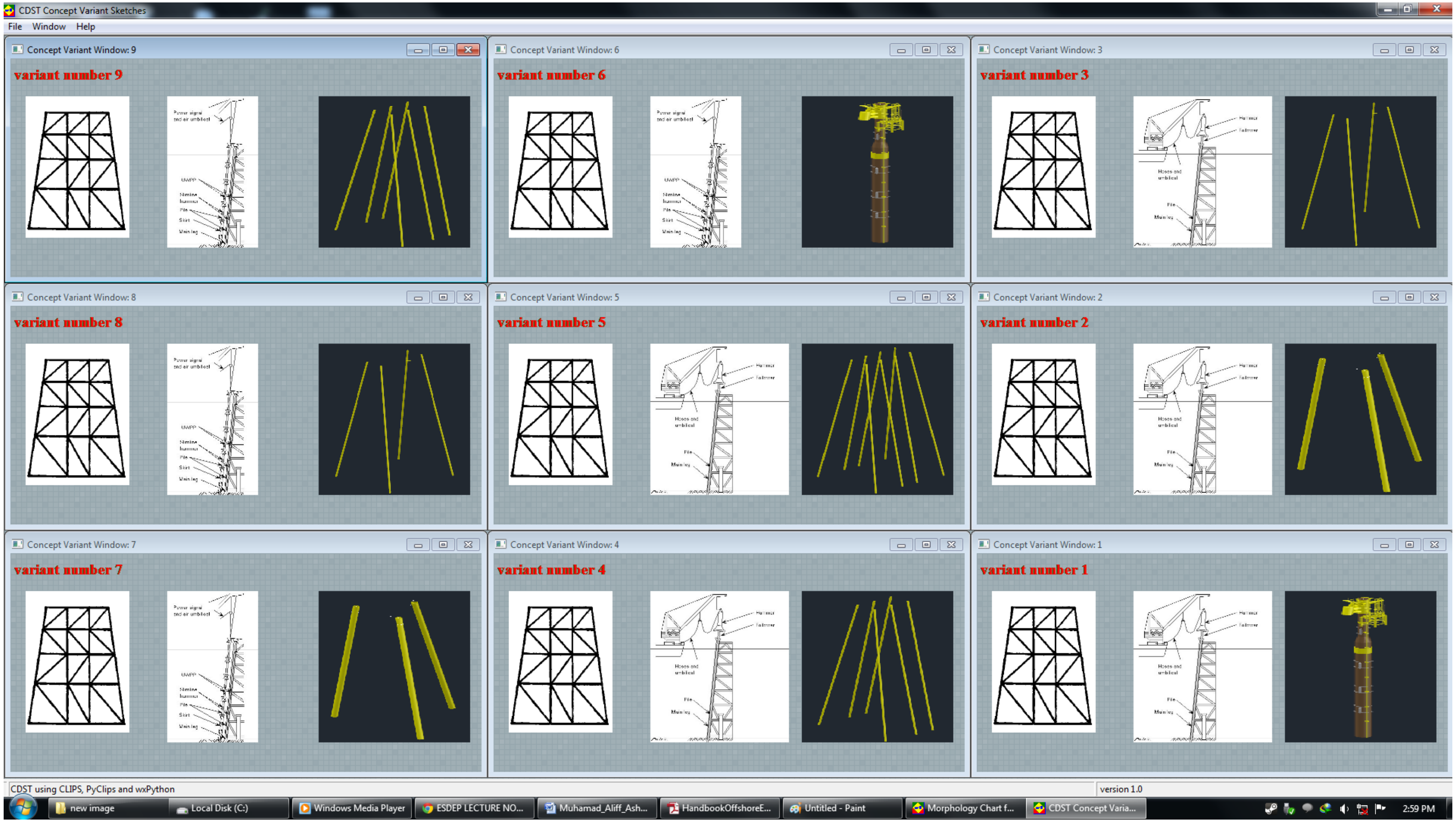


FIGURE 24: Concept variant sketches

After the concept sketches have been reviewed, the variants will then be evaluated using one of the three concept evaluation method available in the software. For this project, the method used was Weighted Decision Matrix. The evaluation criteria which were set manually were:

1) Ease of fabrication
2) Ease of transportation & installation
3) Load bearing limit
4) Weight
5) Cost

Each concept was then given their weight with respect to the criteria set such as shown in Figure 25 below.

CDST Weighted Decision Matrix

File Evaluate Rank Go to Help

		Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6	Variant 7	Variant 8	Variant 9	Variant 10	Variant 11	Variant 12	Variant 13
Evaluation Criteria	Weight	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating
Ease of fabrication	0.20	5	8	7	6	6	4	7	4	7	6	7	9	6
Ease of transportation & installation	0.15	5	6	6	5	7	6	6	6	4	5	8	5	5
Load bearing limit	0.30	3	7	9	3	9	9	9	5	6	3	6	4	7
Weight	0.10	2	3	4	4	4	2	8	3	5	2	4	3	3
Cost	0.25	4	2	2	6	3	4	4	9	1	7	3	6	4
Total Score	0.00	3.85	5.40	5.90	4.75	6.10	5.60	6.80	5.75	4.55	4.80	5.55	5.55	5.35
Rank														

FIGURE 25: Evaluation criteria and weight for concept variants

After all the variants have been evaluated, the software automatically calculated the total score for each variant and ranked them accordingly. Based on the outcome, Variant No. 75 was the first to be ranked with a score of 6.9/10 such as shown in Figure 26 below.

CDST Weighted Decision Matrix

File Evaluate Rank Go to Help

	3	Variant 54	Variant 55	Variant 56	Variant 74	Variant 75
Evaluation Criteria	g	Rating	Rating	Rating	Ratinc	Rating
Ease of fabrication	4	8	7	9	7	9
Ease of transportation & installation	6	6	3	6	6	6
Load bearing limit	7	5	4	4	3	4
Weight	6	3	8	1	4	5
Cost	7	7	3	2	5	10
Total Score	5	6.05	4.60	4.50	4.85	6.90
Rank	0	12	59	62	49	1

FIGURE 26: Ranked concept variants

The concept designs for Variant No. 75 were:

1) X-bracings
2) Vertical skirt piles
3) 8 legged jacket legs

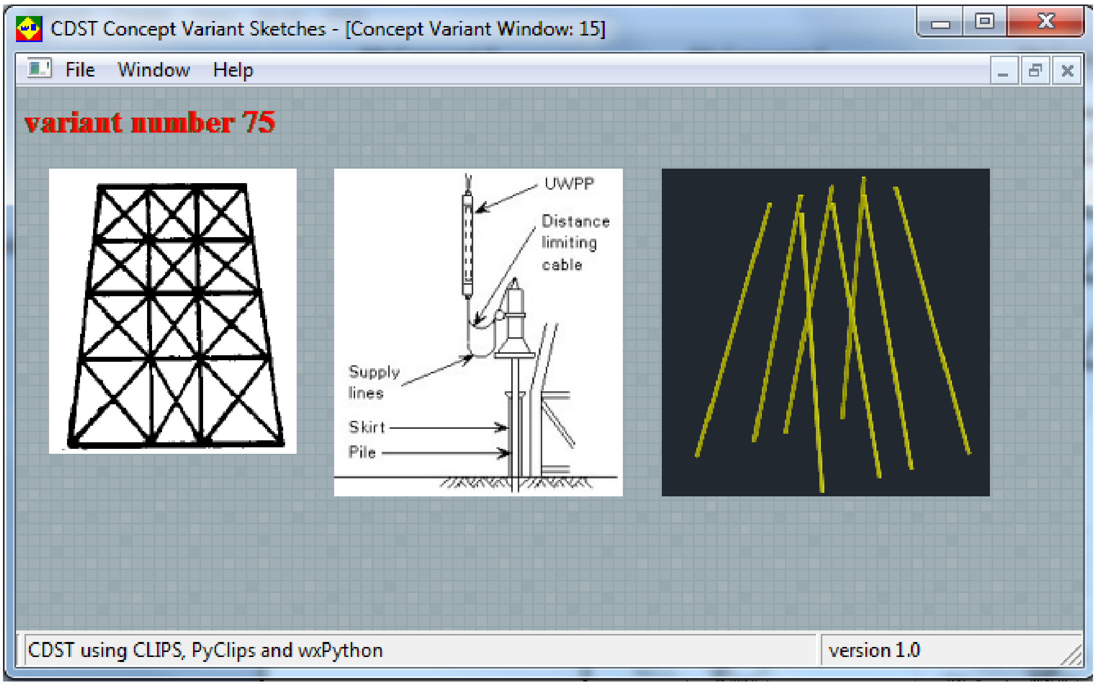


FIGURE 27: Sketch for Concept Variant No. 75

CHAPTER 6

CONCLUSION

Thorough research, literature reviews and data gathering carried out for Conceptual Design Support Tool (CDST) for Offshore Platform Jacket have yielded results for a thorough discussion. A functional decomposition of a generic platform jacket was conducted and the functional functions were cross checked against their physical functions to ensure their validity. The functions were then classified into 3 sub functions with respect to the software's function and flow types.

The first objective of the project which was to expand and enhance the current version of CDST has been achieved. 13 new design concepts have been embedded into CDST's database to allow for designing a platform jacket.

With the new 13 design concepts embedded, CDST was able to generate a morphology chart and 75 new concept variants were created. Each of the concept variants were evaluated using the weighted decision matrix method available in CDST. The software ranked concept variant No. 75 as the number one alternative concept design. This shows that the software was able to generate a realistic design of a jacket with the 13 new concept designs inserted.

To further improve the development of CDST, it is recommended that more design concepts for offshore structures to be included in CDST as it is a good tool that can help minimize design time which by industrial practice usually translates to reduced capital expenditure. The software too should be uploaded to a public online server such as GitHub where the public can download and upload or share their own enhanced version of CDST among each other.

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Appendix A – Jacket Design Breakdown Datum