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Bachelor's Degree of Mechanical Engineering (Structure and Material)"

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DESIGNING AND FABRICATING THE GUARD RAIL SYSTEM FOR THE SCAFFOLD

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DECLARATION

"I declared that this thesis is result of my own research except as cited in the references"

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ABSTRACT

This report is written the designing and fabricating the guard rail system for the scaffold. Scaffold is often used to help workers to reach a high level that cannot be reached by them in order to perform the works like maintenance, cleaning or painting. We often can see that the workers always work at higher ground level without any protection this will risk their precious like. In order to provide a more safety working environment I intend to design and fabricating the guard rail system that can prevent the workers from falling from the top of the scaffold which can cause serious injury or dead. The guard rail system that I intend to design is a guard rail syatem that can be secured easily, easy to bring along, easy to unsecure from scaffold and easy to store. The total cost of designing and fabricating the product must be lower if we want to attract the potential buyer. Along the designing process I will use the Solid Work to produce the drawing of the design, and will using the FEA soft ware Patran and Nastran to analyze my product.

ABSTRAK

Laporan ini tentang mereka bentuk dan fabrikasi satu sistem perlindungan untuk panggar. Panggar selalu digunakan untuk membantu pekerja untuk memcapai ke tempat tinggi supaya boleh melaksanakan kerja-kerja seperti pemeliharaan, pembersihan dan mengecat. Kita selalu boleh mengesan bahawa pekerja-pekerja selau melaksanakan kerja di tempat tinggi tanpa ada sistem perlindungan dan ini akan mengancamkan nyawa pekerja. Oleh demikain untuk menaik taraf tahap keselamatan saya bercita-cita untuk mereka bentuk satu sistem perlindungan untuk panggar supaya boleh menggelakkan pekerja-pekerja dari jatuh semasa kerja di atas panggar yang boleh mengakibatkan kematian kecederaan parah dan kematian. Sistem perlindungan yang saya mereka bentuk ada beberapa keistimewaan iaitu senang untuk ketatkan, senang untuk bawa dan boleh ditanggalkan dengan mudah. Jumlah pembelanjaan dalam menghasilkan produk mesti rendah jika mahu menerik minat pembeli yang berpotensi. Semasa mereka bentuk, saya akan menggunakan "Solid Work" dan menggunakan "Patran" dan "Nastran" untuk menganalisiskan produk saya.

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CHAPTER 1

1.0 INTRODUCTION

Scaffolding is widely used to help us to perform the job at higher place for example when we need to do the maintenance at the higher place and carry the material to the higher place we can set up the scaffolding to help us but at the same time we also expose ourselves in the dangerous situation. When we move to higher place we cannot balance ourselves well and we will fall easily and this can cause serious injury and death so it is necessary to design guardrail for the scaffolding to prevent this incident occurs.

1.1 *OBJECTIVE*

The main objective is to design and analysis the guardrail that we had analyzed in order the guardrail that can be installed in the scaffolding and it will not fail when operates in order perform its' function (fall prevention) so in the end we can produce the product that can perform as we expected. Other than that from the project given we can apply the knowledge that we had learnt to complete this project for example we use the Solid Work, Patran and Nastran software to help us to design and analysis.

1.2 *SCOPE*

Our scope covers the designing and fabricating the guardrail for the scaffolding which allows us to protect the users from falling from the higher place which can bring injury and death. The guardrail should be able to bring from lower level to higher level or vice versa. This project should be completed with the aid of CAE and CAD program such as Solid Work, Patran and Nastran. In the end of the project we should able to produce the product by using the joining and machining process and it can function as we expect.

1.3 *PROBLEM STATEMENT*

From our observation the we learn that most worker always perform their job without the protection so this expose them to the dangerous situation so we come out an idea to solve this problem it is produce the guardrail to protect the edge of each scaffolding so the workers will not fall down to the ground and cause serious injury. The fall protection is necessary because such cases occur frequently and this will bring great loss for the company and family of the employee. In order to design the guardrail we need to come out with the idea of design which we need to use the minimum cost to produce the guardrail which can fulfill our requirements (can perform fall prevention). The guardrail that we design need to be convenient and user friendly, in order to achieve this we can make the guardrail that can bring it from one level to another level. Our design need to be analyzed (for my project I decide to use FEA software like Patran and Nastran to do the analysis) before we can produce it. During the process to produce the product we also need to consider the type of joining process and the manufacturing process that need to produce the product because choosing the correct manufacturing process we can save the time. After we produce the product we need to do inspection or testing I propose the NDT (non destructive test) to do the inspection (detect the any surface or internal defect that produce during the manufacturing process).

1.4 *BACKGROUND*

From our information we know that there are nearly 300 people were killed at the construction site due to fall from the construction site, this makes us intend to design a guardrail system to protect the workers being killed by this type of accident. We intend to design the guardrail with the following specification:

- Can be installed easily.
- Easy to store and bring to the construction site.
- High set up cost is not necessary.
- Perform fall prevention without fail.

In order to achieve the specification above I will select the material with hollow and not solid to decrease the weight of the guardrail, other than that I will try to using pin to connect the structure so the guardrail can be fold and this will make the guardrail easy to store and bring to the construction site. To ensure the safety usage of the guardrail I will analyze the design using the FEM software, Patran and Nastran. By using the FEM software we can know the part with high stress concentration so from the analysis we can know our guardrail will fail or not when it comes to use.

CHAPTER 2

2.0 LITERATURE REVIEW

Introduction of this chapter:

In this chapter I will try to rewrite all the information that I gather from many resources base on my understanding. The topics that will be covered in this chapter are:

- *Safety and Health Act 1994 (Law of Malaysia)*
- *Scaffolding*
- *Product Design Process*
- *Joining Process*
- *Finite Element Method*
- *Testing / Inspection*

The topic that stated in above will be discussed in detail at the following section.

2.1 SAFETY AND HEALTH ACT 1994

Construction industry is one of the most active industries in our country, Malaysia and it is the major force for our country's economy, but we can't neglect the truth that many workers suffer serious injury and death during the period they execute the job. This can be proved by the report of Social security organization, SOCSO, the compensation that paid out by SOCSO is RM650 Million for industrial accident and disaster. In order to control the accident industry

efficiently at 25th February 1994 Occupational Safety and Health Act 1994 came in force to provide protection on safety and health for work activities in every sector of industries.

We need to study for the Act 514 Occupational Safety and Health Act 1994 Part IV General Duties of Employers and Self-employed Persons. The details of Safety and Health Act 1994 Part IV below are adapted from (*http://www.dosh.gov.my/Informasi/Akta/AktaKeselamatan.pdf*):

Section 15. General duties of employers and self-employed persons to their employees.

(1) It is the duty of every employer and every self-employed person to ensure, so far as is practicable, the safety, health and welfare at work of all his employees.

(2) Without prejudice to the generality of subsection (1), the matters to which the duty extends include in particular-

(a) the provision and maintenance of plant and systems of work that are, so far as is practicable, safe and without risks to health;

(b) the making of arrangements for ensuring, so far as is practicable, safety and absence of risks to health in connection with the use or operation, handling, storage and transport of plant and substances;

(c) the provision of such information, instruction, training and supervision as is necessary to ensure, so far as is practicable, the safety and health at work of his employees;

(d) so far as is practicable, as regards any place of work under the control of the employer or self-employed person, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of the means of access to and egress from it that are safe and without such risks;

(e) the provision and maintenance of a working environment for his employees that is, so far as is practicable, safe, without risks to health, and adequate as regards facilities for their welfare at work.

(3) For the purposes of subsections (1) and (2)-

(a) "employee" includes an independent contractor engaged by an emplbyer or a self-employed person and any employee of the independent contractor; and (b) the duties of an employer or a self-employed person under subsections (1) and (2) extend to such an independent contractor and the independent contractor's employees in relation to matters over which the employer or self-employed person-

(i) has control; or (ii) would have had control but for any agreement between the employer or self-employed person and the independent contractor to the contrary.

The offender under this section will be punished. Penalty for an offence under section 15 is stated in section 19 in the Act 514 Occupational Safety and Health Act 1994 Part IV General Duties of Employers and Self-employed Persons. The details are shown in below:

Section 19. Penalty for an offence under section 15.

A person who contravenes the provisions of section 15, 16, 17 or 18 shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding fifty thousand ringgit or to imprisonment for a term not exceeding two years or to both.

From the law and act stated above we believe that the accident (fall from scaffolding) will bring disaster to employee and employers' family; in order to prevent this disaster we believe it is necessary to design a guardrail to prevent this type of incident occurs again.

2.2 SCAFFOLDING

In order to design the suitable guardrail I need to study the scaffolding in term to know the needs and requirements to fulfill and find out the dimension of the scaffolding.

Scaffolding is defined as the temporary frame that used to support people and material in the higher place above the ground level. It is obvious that, it is impossible for us to reach the higher place above the ground level without the help of scaffolding if we intend to perform our

task or job at such a high level from ground. The key elements of the scaffold are Standard, ledgers and transoms (adapted from: *http://en.wikipedia.org/wiki/Scaffolding*). The standard is the upright vertical tube which the entire mass of the structure to the ground in order to give support. Ledgers are the part that used to connect between the standards and transoms are the parts which place ninety degree to the ledger to give extra support to the boards. Figure 2 below shows the key elements of the scaffolding.

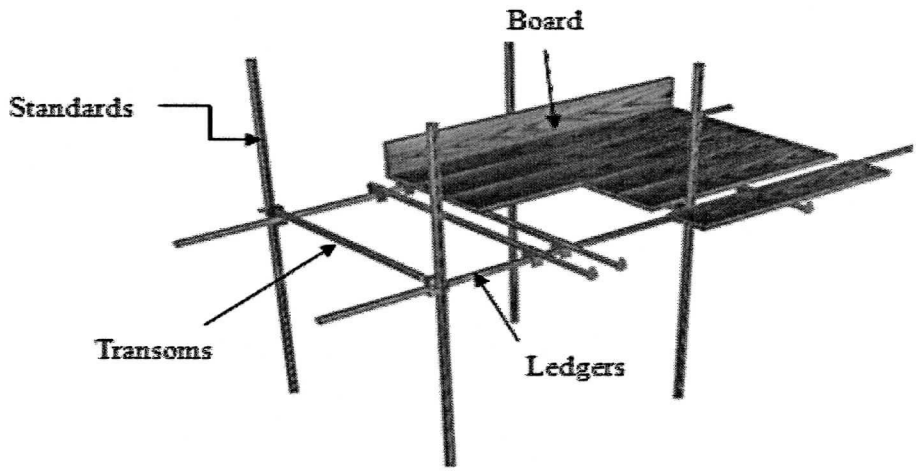


Figure 2: Key Elements of Scaffolding

Source:
http://www.asp.gb.com/images/XTuse.jpg

There are several terminologies that we must take note (shown below) and the graphical illustration will be given in Figure 2.1.

- Bay length
- Base lift
- Scaffolding width

- Lift height

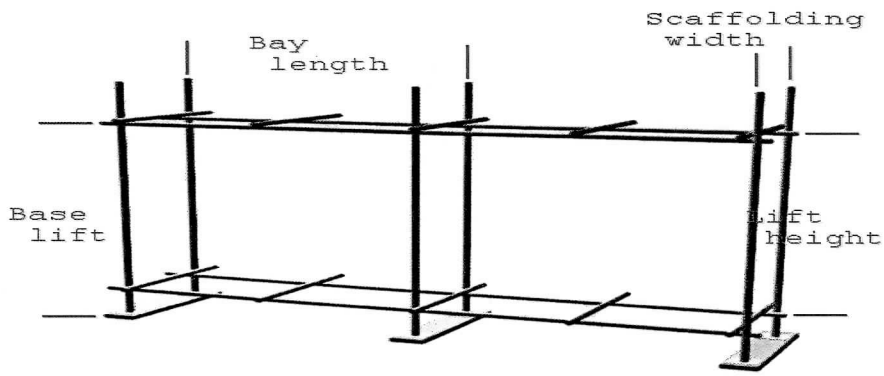


Figure 2.1 Bay Length, Base Lift, Scaffolding Width, and Lift Height

Source: Wikipedia

The bay length of our project 1.8m, lift height 2m and scaffolding width equal to 1.2m. The boards will be placed in between the ledgers and transoms in order to provide the working surface to the users. The boards' ends are protected by the hoop irons or sometimes called nail plate while the plate is laminated by aluminium or steel to prevent split because the cause to replace is much higher.

When we need to set up the scaffolding we need to connect the tubes together so the couples will be used which mean it is the fitting to hold the tubes together to support the load. There are three basic types of couplers namely right-angle couplers, putlog couplers, swivel couplers. If we want to joint tubes end-to-end sleeve couplers are used. Table 2 below shows the type of couplers and their function.

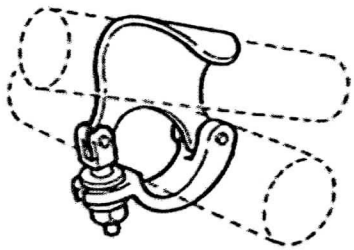
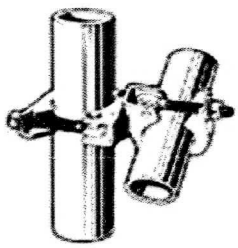
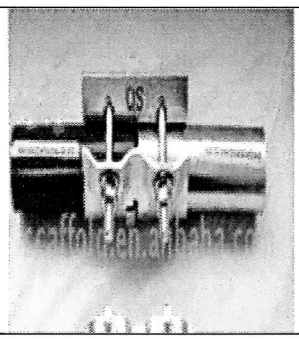
Types of Couplers	Function of Couplers
	*Right-angle Couplers* – Use to join ledgers or transoms to standards.
	*Putlog Couplers* – Used to join board bearing transoms to ledgers.
	*Swivel Couplers* – Used to connect tubes at any other angle.
	*Sleeve Couplers* – Used to joint tubes end-to-end.

Table 2: Types of Couplers and Its' Function

Source:
http://img.alibaba.com/photo/10326086/Right_Angle_Couplers_Swivel_Couplers.jpg

2.3 PRODUCT DESIGN PROCESS

The product design process is the critical activity that we need to take note because at this stage we can estimate 70%-80% of the cost of product in the initial stage. When we design the product we need to be innovative, innovative is highly desire in the design stage because it can save the production cost and the material while it still can perform as we desired. In other words we can produce the product with lower cost but can function well and it will be highly demand in the market.

Before we do the design, we need to understand our product well and the function and perform that we had expected. Example for my project I need to design the guardrail for the scaffolding which can prevent worker from falling while the guardrail will not fail (the part of the structure will not rupture under stress). In order to achieve the above objective, I need a systematic approach to achieve my objectives. Figure 2.2 below shows the flow of activity that I had planned

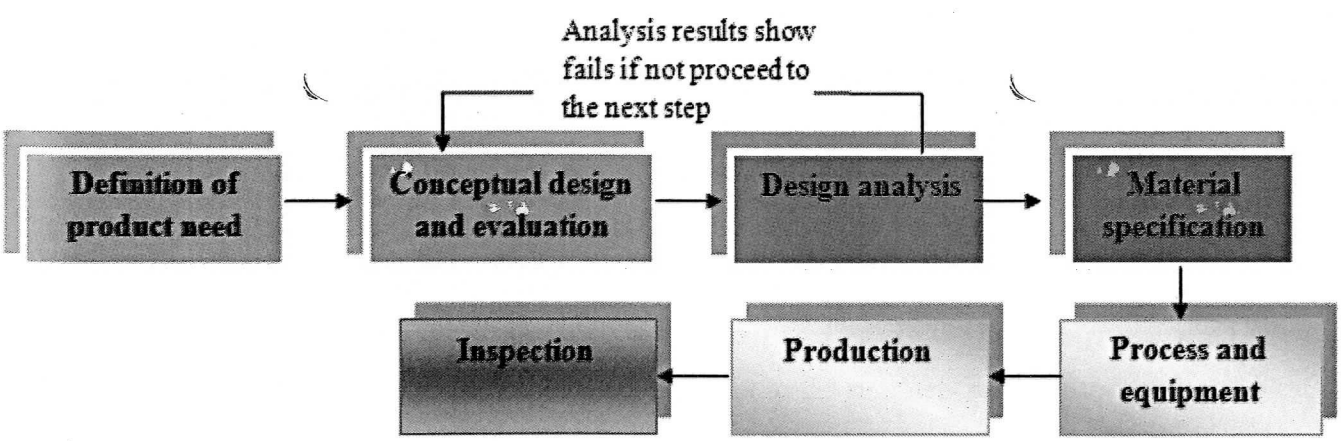


Figure 2.2: Flow of the Activity in Design Process

Following the Flow of activity above I had done I need to define the activity well, below is the definition of the activity:

- Definition of product need : Guardrail can perform fall prevention without fail.
- Conceptual design and evaluation : Do the drawing with the aid of Solid Work 2005.
- Design analysis : Using Patran and Nastran to do the analysis.
- Material specification : Select the suitable material.
- Process and equipment : Choose the suitable process to produce the product.
- Production : Produce the product
- Inspection : Using destructive testing or non destructive testing.

From the above we know that during design process we using CAD and CAE program to help us to do the design and analysis. The example for CAD program is like Solid Work 2005 that I had used to help me to do the design. The CAD program is used the computer technology to design the object either it is real or virtual. CAD may use design curved and figures in two dimensional space or curves, surfaces or solids in three-dimensional. The CAE program I used in my project are Patran and Nastran the CAE stands for the Computer Aided Engineering, it's used the information technology to support the engineer to complete the tasks such as analysis, simulation, and design.

During the design stage we need to take consideration of several important things, there are assembly, disassembly and service (design for manufacture). Design for assembly is the important element to consider because the individual components that we manufactured need to be assembled to produce the whole product. The concept of design for assembly is wanted to ensure the product can ease to put all the parts together with shorter time and lower cost. Design for disassembly is part of the important criteria that need to take consider but normally if the product can be assembled easily it also can be disassembled easily. In our design we need to know that our products need to do maintenance in order to the products can perform well and it will not fail, so from this statement the design of service is very important in order to ensure each individual parts or sub-assemblies in a product be easy to reach and service to maintain it performance (adapted from: Kalpakjan, S. & Schmid, S. (2006) *Manufacturing Engineering And Technology*. Pearson Prentice Hall Publishing.).