SUPERVISOR DECLARATION

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design & Innovation)"

Signature : .....

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Date : 31.05.2012

DESIGN AND ANALYSIS OF DUMBWAITER LIFT FOR PUBLIC BUILDING USE

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This report is submitted to the Faculty of Mechanical Engineering
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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been cited".

Signature : .....

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DEDICATION

Highest special thankful wishes to both my lovely parents

Wan Azahar Bin Yacob

&

Suhana Binti Hashim

Also

Fellow classmates

Mechanical Design & Innovation (2008-2012)

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ABSTRACT

A dumbwaiter lift can be defined as a device that consists of a cart and pulley system to move goods between floors in a building. Dumbwaiter lifts are usually found in mansions or public buildings such as hospitals and hotels. In this project, the first objective is to design and propose several conceptual designs of a dumbwaiter lift used in public buildings. The second objective of this project is to analyze the conceptual designs and obtain the factor of safety in order to find the best design. The background of this project is explained through the objectives, scope and methodology involved. Literature reviews are done on existing models in the market in order to get more information about dumbwaiter lifts. Conceptual design is then produced from existing models and an optimum design is chosen. Ergonomics analysis and stress analysis are then conducted on the final design to determine the effectiveness of the concept. CATIA software was used at the final stages of the of design and analysis purpose. Results from the analysis are used to determine the factor of safety of both existing and selected design. The factor of safety of the existing design is 1.36, and the selected design is 1.97. From the RULA analysis, the final score is improved, from a final score of 6 reduced to 5 on the right side, and a final score of 7 is reduced to 5 on the left side, based on the given criteria in the software. Thus, the results of the analysis have improved the limitations of existing models with a safe design. In conclusion, the chosen design out of the 3 conceptual design is a more safer design to be used in a public building.

ABSTRAK

Lif *dumbwaiter* boleh ditakrifkan sebagai alat yang terdiri daripada sebuah troli dan sistem takal untuk menggerakkan barang antara tingkat dalam bangunan. Lif *dumbwaiter* biasanya ditemui di rumah agam atau bangunan awam seperti hospital dan hotel. Objektif pertama projek ini ialah untuk merekabentuk dan mencadangkan beberapa konsep rekabentuk lif *dumbwaiter* untuk digunakan di dalam bangunan awam. Objektif kedua projek ini adalah untuk menganalisis konsep terbaik dan mendapatkan faktor keselamatan. Latar belakang projek ini dijelaskan melalui objektif, skop dan metodologi yang terlibat. Kajian ilmiah dilakukan ke atas model yang sedia ada di pasaran untuk mendapatkan maklumat lebih lanjut mengenai lif *dumbwaiter*. Konsep-konsep ini kemudiannya dihasilkan daripada model yang sedia ada dan reka bentuk optimum dipilih. Analisis ergonomik dan analisis tekanan kemudian dijalankan ke atas rekabentuk akhir untuk menentukan keberkesanan konsep. Perisian CATIA telah digunakan di peringkat akhir rekabentuk dan analisis. Hasil daripada analisis digunakan untuk menentukan faktor keselamatan kedua-dua rekabentuk yang sedia ada dan yang dipilih. Faktor keselamatan reka bentuk yang sedia ada adalah 1,36, dan reka bentuk yang dipilih adalah 1,97. Daripada analisis RULA, skor akhir ini bertambah baik, daripada skor akhir sebanyak 6 dikurangkan kepada 5 di sebelah kanan, dan skor akhir sebanyak 7 dikurangkan kepada 5 pada sebelah kiri, berdasarkan kriteria yang diberikan dalam perisian CATIA. Oleh itu, keputusan analisis telah meningkatkan had model yang sedia ada dengan reka bentuk yang selamat. Kesimpulannya, reka bentuk yang dipilih reka bentuk 3 konsep reka bentuk yang lebih selamat untuk digunakan dalam bangunan awam.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In these modern times, people are constructing items to help simplify daily routines or chores. For example, escalators and elevators have been used widely in buildings instead of stairs for mare comfort and speed of getting people from one floor to another. A dumbwaiter is a smaller form of an elevator; however, it is not used for transporting people, but is usually to carry goods such as laundry, groceries or meals to and from different floors.

Dumbwaiters can be operated by manually pulling ropes to elevate the carts and also operated by using electricity, which the user only needs to push a button to operate the dumbwaiter. A simple dumbwaiter usually includes a cart to put items, a guide rail for ease of cart movement, motor for electric operated dumbwaiter, a controller, stations to where the goods are sent, interlocks for safety purposes, and limit switches as sensors (Pinciotti, 2011).

In order to design a dumbwaiter, specifications of the building must be acknowledged to determine the position, size and other criteria that are important for the optimum functionality of the dumbwaiter. The materials used should be practical and lasting for the functional portion of the dumbwaiter, as it is hidden in the frame.

Decorative materials can be used for the outer part, such as doors and buttons for the dumbwaiter.

1.2 PROBLEM STATEMENT

It is very important to know the problem statement before conducting a study. The first problem with the existing dumbwaiter is the ergonomics factor. Due to its smaller size compared a normal people elevator, the size, loading and unloading item process needs to meet the ergonomics of the people because the dumbwaiter lift will be used by members of the public.

The second problem is that the dumbwaiter needs to be able to carry goods that weigh at least 100kg. Strength of the pulling mechanism and the cart itself needs to be sturdy to withstand the load.

Improvements should be done in the stability, smoothness of motion and also strength of the structures of the dumbwaiter itself. From these problem statements, this project will have a clearer path in order to design a much better design.

1.3 OBJECTIVES

Objectives can be defined as the goals or target that needs to be achieved at the end of the project. The objectives need to be fulfilled in order to complete the project at hand. The objectives of this project are:

- To design and propose a few conceptual designs of a dumbwaiter lift for public building usage
- To analyze the conceptual designs and obtain the Factor of Safety

For the first objective, the goal is to produce a few conceptual designs of the dumbwaiter in order to find practical models that can be installed in a public building. The concept will be based on existing dumbwaiters in the market in order to find rooms of improvements.

The second objective is to perform ergonomics and stress analysis on the proposed design in order to calculate the Factor of Safety for the dumbwaiter lift for public building usage.

1.4 SCOPE

This study will be based on the existing dumbwaiters available in the market and new concept development of the dumbwaiter. The scope of this project is to cover case study through literature reviews and journals on dumbwaiters, elevators or lifts and also the analysis involved.

The scope of this study includes using the CATIA software to develop conceptual designs to be presented. Furthermore, the CATIA software will also be used to analyze the ergonomics, as well as stress and strain on the proposed design. Both analyses are carried out in order to get the factor of safety and to introduce a design that is comfortable to use by the people who are using the dumbwaiter lift.

At the end of the study, a new design will be proposed based on the current model available. The proposed design is expected to be better than the models available in the market in term of ergonomics condition. It is also expected that the proposed design to be a safe design as it is for public building use.

1.5 METHODOLOGY

The research of this project will be conducted through literature reviews, journals and also web searches. Furthermore, information will be produced from suppliers, contractors and also maintenance crew through interviews, so that hands on problems can be detected and improved further.

In order to achieve the optimum design, the phases and interactions of the design process will be followed accordingly. This includes identification of need, definition of problem, synthesis, analysis and optimization, evaluation and presentation. In order to determine the needs of customers and engineering, a House of Quality or Product Decomposition will be constructed to evaluate the important needs of the new dumbwaiter concept.

This project will use CATIA software to design the concept of dumbwaiter lift and also to run the analysis needed to complete the study. Via software, calculations and the design can be conveyed in a clearer and faster way compared to manual design and calculation.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A dumbwaiter lift can be defined as a mechanism that uses a pulley system as a transportation device for carrying goods between floors of a building. The modern version of the device is usually driven by a motor, while early designs use manual labor to drive the cart with the help of a pulley system. A dumbwaiter lift is usually installed where goods need to be moved constantly to different floors or to a private room without using humans to transport them. This is due to privacy concerns, delivery time constraint, labor reduction and ease of delivery.

It is estimated that the dumbwaiter lift usage started at the beginning of the 19th century or earlier. The "Encyclopedia of College, Farm and Villa Architecture and Furniture" in 1834 called the dumbwaiter lift in London as "Rising Cupboards". The said published article also contains sketches of the contraption that operated on the same principle of the dumbwaiter lift.

Originally, the dumbwaiter lift is used in commercial establishments and in tall, narrow city houses that had many flights of stairs. Its function is primarily to carry things to and from the ground floor kitchen. This includes sending food to the formal dining room situated at a level above the kitchen, transport supplies from the cellar to the kitchen, transporting supplies throughout the house floors, laundry collection and sending garbage to the cellar (The Old House Journal, 1981).

Now, the dumbwaiter lift is used in households with a basement to transport groceries, general buildings such as hospitals and libraries and also in some hotels, applied to their grand suites to better serve patrons. With the help of modern electronics, users only need to load the dumbwaiter cart with the items that need to be transported, and push the control button to determine the floor destination of the goods.

2.2 DUMBWAITER LIFT COMPONENTS

According to Jill Pinciotti (2011), electric dumbwaiter lifts have a track system to assist the cart's movement and are powered by an electric motor to raise or lower the dumbwaiter cart. Also, a dumbwaiter lift is designed almost like a normal elevator lift, with safety brakes and interlocks to prevent the cart from moving when the door is open.

George W. Gibson (2009) states in his article that the structure of load bearing structures, such as suspension ropes, cart frames, bracings, platforms, cart, guide shoes and miscellaneous supports, including a counterweight.

Referring to planning guides and installation instructions from various sources and the Department of Safety and Health (DOSH) Melaka, it can be deduced that the main components of a dumbwaiter lift are:

1. Cart
2. Guide rail
3. Motor
4. Controller
5. Stations
6. Interlock
7. Frame or enclosure

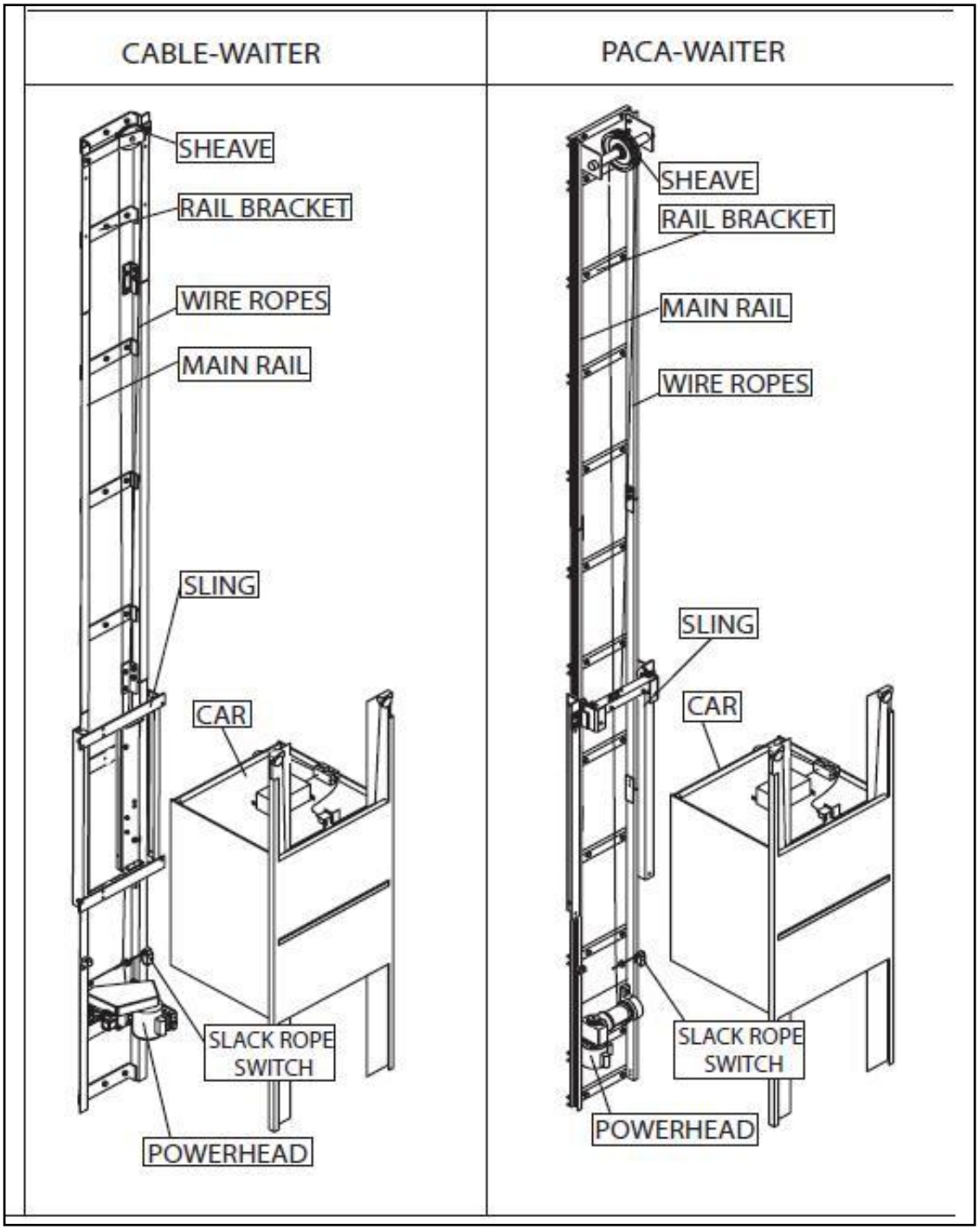

Figure 2.1 Full Assembly of Dumbwaiter Lift

(Source: Waupaca Elevator Company Inc. , 2011)

The components shown in the above figure is commonly used in building dumbwaiters, with different configurations depending on the building structure, dumbwaiter usage, and other design concerns. The parts explained in this section are from the Waupaca Elevator Company Inc. dumbwaiter model.

2.2.1 Cart

The cart is one of the key components of a dumbwaiter lift. It is shaped like a box, with one or more doorway depending on the design and customer requirement. It functions as the carrier of the goods between floors.

The cart will be attached to the sling and rail bracket with a wire rope. The figure below shows a dumbwaiter cart when it is dismantled from the whole contraption.

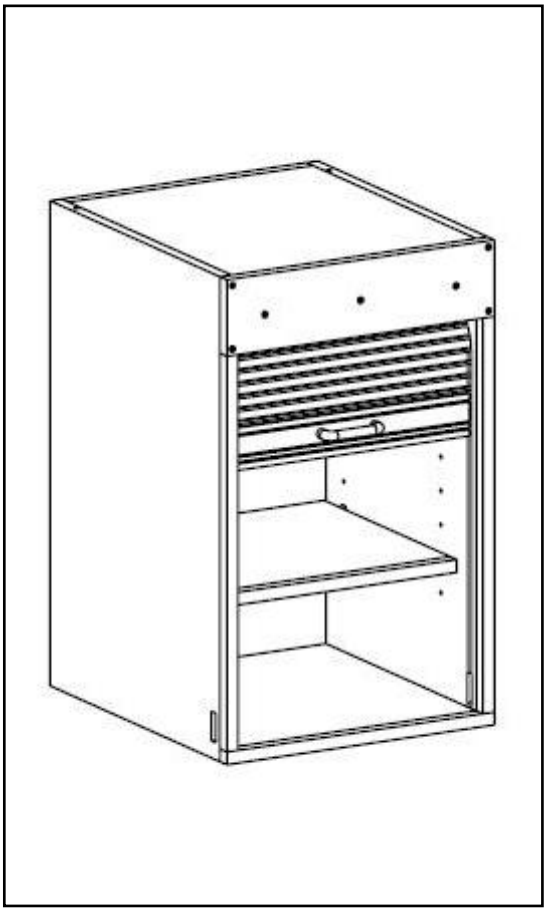

Figure 2.2 Dumbwaiter Cart

(Source: Waupaca Elevator Company, Inc., 2011)

2.2.2 Guide Rail

The guide rail is used to provide a convenient movement of the cart when it goes up and down between floors, without it banging on the side of the enclosure or frame.

The guide rail will be installed along with the frame a form of truss to further enhance the structure of the complete dumbwaiter lift. There are a few types of guide rails available, as shown in the figure below.

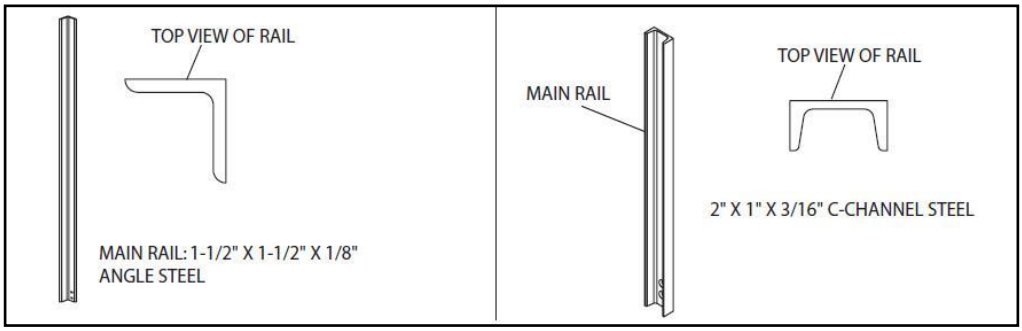

Figure 2.3 Guide Rail

(Source: Waupaca Elevator Company, Inc.)