SLAB REINFORCED WITH HDPE PIPE (SREHP)

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ABSTRACT

Reinforced slab are used in floors and walls of building for construction work. The floor system of a structure can take many forms such as in situ solid slab and pre-cast unit. Steel is common reinforcement material used comprehensively for construction today. High Density Polyethylene (HDPE) as thermoplastic polymer matrix systems can be introduced as an alternative replacement material for steel as structural elements to overcome the common conventional materials' problems. The slab reinforced with HDPE pipe (SREHP) will be test using third-point load test was adopted to assess this study. For this test, we can get the flexure strength and deflection of SREHP to compare with conventional slab. The result for this testing shows that, HDPE is not good to be used as replacement material. It will reduce the strength and increase the deflection. Besides that, the tensile test show the strain of HDPE was weak to compare with steel reinforcement. The HDPE pipe has proved that, the mechanical characteristics that is suitable for light structural element and should be comparing with another material. Furthermore, HDPE pipe also probably generate a new product by changing the type of conventional reinforcement slab to hollow reinforcement slab. HDPE pipe still can be applied in lightweight structure in the future such as lightweight slab as it can withstand a small load.

ABSTRAK

Papak bertetulang digunakan dalam lantai dan dinding bangunan bagi kerja-kerja pembinaan. Sistem lantai struktur yang boleh mengambil pelbagai bentuk seperti dalam papak padu in-situ dan papak pra-tuang. Besi adalah bahan tetulang yang biasa digunakan secara menyeluruh untuk pembinaan hari ini. Polietilena Ketumpatan Tinggi (HDPE) sebagai termoplastik sistem matriks polimer boleh diperkenalkan sebagai bahan gantian alternatif untuk besi sebagai elemen struktur untuk mengatasi masalah bahan-bahan konvensional biasa. Papak diperkukuhkan dengan paip HDPE (SREHP) akan menjadi ujian menggunakan ujian beban titik-ketiga untuk menilai kajian ini. Untuk ujian ini, kita boleh mendapatkan kekuatan lenturan dan pesongan SREHP untuk membandingkan dengan papak konvensional. Hasilnya ujian ini menunjukan, bahawa HDPE tidak baik untuk digunakan bahan pengganti. Ia akan mengurangkan kekuatan dan meningkatkan pesongan. Selain itu, ujian tegangan menunjukkan tegangan HDPE adalah lemah berbanding dengan besi tetulang. Paip HDPE telah membuktikan bahawa, ciri-ciri mekanikal yang sesuai untuk elemen struktur ringan dan perlu bandingkan dengan bahan lain. Tambahan pula, paip HDPE juga mungkin menjadi satu produk inovasi baru dengan menukar jenis papak tetulang konvensional kepada papak tetulang berongga. Paip HDPE masih boleh digunakan dalam struktur ringan di masa depan seperti papak ringan kerana ia boleh menahan beban kecil.

TABLES OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

HDPE	High Density Polyethylene
SREHP	Slab Reinforcement with HDPE Pipe
LVDT	Linear Variable Displacement Transducer
OPC	Ordinary Portland Cement

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Overall this project will cover about slab reinforced with HDPE pipe (SREHP). In this chapter will include the introduction about slab reinforcement along with the project background, problem statement, the objective of the project, the project scope, the outcome of this project, significant of the project and lastly will concluded about slab reinforcement.

Slab is the one of the most widely and popularly used in the building industry which is used as a floor or wall slab panel in applications in residential, commercial and industrial structure. The span of slab can be divided into one way and two way directions and they can support concrete beam, steel beams walls or directly by the structure's columns.

The technology of IBS was introduced by the Construction Industry Development Board. It is a construction technique in which components are manufactured in a controlled environment, transported, positioned and assembled into a structure with minimal additional at site. IBS is also known as modern method of construction and off-site construction.

1.2 BACKGROUND OF STUDY

Reinforced slab are used in floors and walls of building for construction work. The floor system of a structure can take many forms such as in situ solid slab and pre-cast unit. As we know, IBS is good for construction because it's easy to install, but relatively expensive. It creates hollow core slab and composite slab.

Concrete possess high compressive strength but on the other hand, low in tensile strength. Although steel have good property in resisting tensile force, being exposed for a long period of time would result in corrosion easily.

High Density Polyethylene (HDPE) as thermoplastic polymer matrix systems is introduced as an alternative replacement material for steel as structural elements to overcome the common conventional materials' problems. In addition to the better HDPE's general properties compared to steel, architectural modification for replacement HDPE pipe will help to avoid damage due to corrosion.

1.3 PROBLEM STATEMENT

Steel is common structural material use comprehensively for construction today. The use of steel covers almost every sub-structure and super-structural due to its wide availability. Steel is used in a variety of other construction materials, such as bolts, nails, screws, and reinforcement. However like every other material, steel has a few significant downsides.

Corrosion is a main negative condition occurs on steel. Generally, corrosion can be described as the product of electrochemical oxidation of metals in reaction with an oxidant such as oxygen. Thus, the diversity of surroundings plays a major role on steel corrosion. HDPE pipe is a better option compared to steel since HDPE pipe made of polyethylene thermoplastic and it does not affected by corrosion process.

Steel is a rigid and heavyweight material. IBS slab that use steel still required a lot of preparation process. It will increase the cost and time required in construction work. Meanwhile, HDPE pipe offers a solution through its flexibility and light weight of the material.

1.4 OBJECTIVE

There are several objectives:

i. To identify the flexure strength of SREHP
ii. To analyse the deflection of SREHP
iii. To compare mode of failure between reinforced slab and SREHP

1.5 SCOPE OF STUDY

In this project four full scale slabs (1.5m span, 0.6m wide and 0.15m thickness) were used in the experimental program, using HDPE pipe for reinforcement in slab. The size of pipe use 1inch and include appropriate spacing of the stud. The cube test sample of G20 will be used as measured the Strength of the concrete.

1.6 EXPECTED OUTCOME

At the end of the study, there are some outcomes to be achieved, such as:

1. In addition, the reason using HDPE because that pipe will help to avoid damage due to corrosion.
2. The High Density Polyethylene (HDPE) used for the precast slab will provide a good flexure strength and deflection of that slab.
3. Furthermore, HDPE pipe also to use to generate the new product by changing the type of hollow core slab.

1.7 SIGNIFICANT OF STUDY

The significant of this project is about replacement material of pipe from steel to HDPE, where HDPE provide a good corrosion resistance, flexible and light compare to the used steel.

In this report consist four main chapters; begin with the review by previous researcher from a range of projects and problem raise by the slab reinforced with HDPE pipe (SREHP) industry. In chapter two will discussed further detail on the concrete as a structure material, type of slab, reinforcement and testing.

The methodology which is the process flow chart of this project will be discussed in chapter three, briefly about the reinforcement preparation, material, and sample preparation together with testing method.

In chapter four where it is reflected to chapter two, in order to determine the result from previous study and the current testing result from this project. All the data collection will be discussed in this chapter as a result of this project. The conclusion from all the accomplish result were briefly elaborated in chapter five.

1.8 CONCLUSION

For the conclusion, HDPE have general properties compared to steel architectural modification for replacement and will help to avoid damage due to corrosion. The problem statement can be conclude is HDPE pipe offer a solution through its flexibility and light weight of the material and can achieve the objective of this research. In this chapter, the conclusion of expected outcomes can be determined at the end of study to be achieves in this research. The summary of significant of study is about the replacement material of pipe from steel to HDPE, where HDPE provide a good corrosion resistance, flexible and light compare to the used steel. The main conclusion for this chapter identified the problem of steel material used in slab construction by replacing the material to HDPE pipe. The main problem in using steel material is that it easy to rust and heavy. By replacing the material the main problem can be solved and achieve the objective of this project. Next chapter will explain about Literature Review of this project.

CHAPTER 2

LITERITURE REVIEW

2.1 INTRODUCTION

This chapter will discuss on related and relevant previous literature of the research project. It summarizes the literature result finding which can answer the research objectives. The most common structural element for construction is reinforced concrete slab. Slabs are an important structural component where pre-stressed is applied. Slabs are becoming popular for construction in effect of increase in the demand, economical and efficient construction. It provides a working flat surface or a covering shelter in buildings. Construction slab behave primary as flexural members and the design is similar to that of beams.

2.2 CONCRETE AS A STRUCTURAL MATERIAL

Concrete consist of a mixture that contains a mass of loose, inert particles of grade size (commonly sand and gravel) held together in solid form by binding agent. That general description covers a wide range of end products. The loose particles may consist of wood chips, industrial water, mineral fibres, and various synthetic materials. The binding agent may be coal tar, gypsum, portland cement, or various synthetic compounds. The end products range from asphalt pavement, insulating fill, shingles, wall panels, and masonry units to the familiar sidewalks, roadways, foundation, and building frameworks (James and Patrick, 2007).

2.3 MATERIAL AND NATURE OF STRUCTURAL CONCRETE

2.3.1 Cement

According to James and Patrick, 2007, the cement used extensively in building construction is portland cement. Of the five standard types of portland cement widely available in the United States and for which the American Society for Testing and Materials has establish specifications, two types account for the most of the cement used in buildings. These are general-purpose cement for use in concrete designed to grasp its required strength in about 28 days, and high-early-strength cement for use in concrete that attains its design strength in duration of a week or less

All portland cement set and harden by reacting with water, and this hydration process is accompanied by generation of heat. The cement actually used in construction corresponds to that employed in designing the mix, to produce the specified compressive strength of the concrete.

2.3.2 Aggregates

According to David A., 2011, fine and coarse aggregates, which typically occupy 60% to 70% of the concrete volume, have a strong influence on the properties of concrete. Fine aggregates usually consist of sand or crushed stone and have diameters smaller than approximately 0.2 in. Coarse aggregates typically have diameter ranging between 0.375 and 1.5 in and consist of gravels, crushed stone, or a combination thereof.

Normal-weight concrete is concrete made with sand, gravel, and crushed stone that conforms to ASTM C33. The density or unit weight of normal-weight concrete is typically between 125 and 160 pcf and is normally taken as 145 or 150 pcf. Expanded shale, clay, and slate are common aggregates used in the production of lightweight concrete, which has a density of 90 to 115 pcf. Sand-lightweight concrete contains fine aggregates that conform to ASTM C33 and lightweight aggregates that conform to ASTM C330.

Table 2.1: Type of Aggregates

Aggregates	
Normal-weight	ASTM C33-03, Standard Specification for Concrete Aggregates
Lightweight	ASTM C330-05, Standard Specification for Lightweight Aggregates for Structural Concrete.

2.3.3 WATER

According to James and Patrick, 2007, water must be fairly clean, free of oil, organic, matter, and any substances that may affect the actions of hardening, curing, or general finish quality of concrete. Practically, drinking-quality (potable) water is usually adequate. Salt-bearing seawater perchance used for plain concrete (without reinforcing) but may cause the corrosion of steel bars in reinforced concrete.

2.4 TYPE OF SLAB

2.4.1 Slab

The flat slab has been adopted in many building constructed recently due to the advantage of reduced floor height to meet the economical and architectural demands. Structural systems using flat slabs are currently widely used because they are economical, easy and fast to build, (Micael, Ramos, & Faria, 2012).

According to Kim and Lee, 2005, the floor slab has larger flexural deformation around the columns when the structure is subjected to lateral. However, the floor slab is divided into a column strip and middle strip in the analysis and design of flat slab structures.

2.4.2 Hollow Slab

This invention relates to a new system of pre-cast hollow slab concrete construction to provide a simpler, cheaper and lighter construction than other method in general use. According to Jaffer, 2006, precast prestressed hollow core slabs are one of the most commonly used structural systems to cover large spans. Primarily used as floor or roof system in building industry, hollow slab also have application as wall panel, spandrel members and bride deck units. Strengthening of these slabs may be required for several reasons. The main reasons include increased load due to higher dead or live loads, architectural modifications in locations of wall, damage due to corrosion, installation of heavy machinery, and errors in planning or construction due to insufficient design dimension or insufficient reinforcing steel, (Jaffer,2006).

2.5 REINFORCEMENT

For most structural application of concrete, it is necessary to compensate for the weakness of the material in resisting tension. The primary means of accomplishing this is to use steel reinforcing bars. A more recent development is to add any material such as High Density Polyethylene (HDPE pipe) for the replacement reinforcement.

2.5.1 Steel

According to James and Patrick, 2007, the steel worn in reinforced concrete consists of round bars, mostly of the deformed type, with lugs or projections on their surfaces. The surfaces deformations help to develop a greater bond between the steel rods and the formation aid to develop a greater bond between the steel rods and the enclosing concrete mass. The fundamental purpose of steel reinforcement is to reduce the cracking of the concrete due to tensile stresses. Structural actions are considered for the development of tension in the structural members, and steel reinforcement in the proper amount is placed within the concrete mass to resist the tension. In a few situations steel reinforcement may also be used to increase compressive resistance since the ratio of magnitudes of strength of the two materials is quite high. Hence, the steel displaces a much weaker material and the member gains significant strength.

2.5.2 High Density Polyethylene (Hdpe)

According to ASTM D883, High density polyethylene (HDPE) is a type linear polyethylene and has density range from 0.941 60 0.965g/cc. HDPE make the suitable modulus and apt for use in the manufacture of plastic pipes and showing the high strength. Polyethylene pipe shall meet the r requirement of AASHTO M249, or ASTM F 714 or F897, (AASHTO LRFD)

Table 2.2: Corrugated HDPE Pie Properties According to STM D 3350 based on ASHTO M 294 Specification

Property	Test Method	Biology (%)	Education (%)
Density	ASTM C 1505	3	>0.9477-0.950 (g/cc)
Melt index	ASTM D 1238	4	<0.15 (g/10 min.)
Flexure Modulus	ASTM D 790	5	110,000 - <160,000 psi
Tensile strength	ASTM D 638 Type IV	4	3000 - <3500psi
SCGR*	ASTM D 1693 or F 1435	0	Unspecified
HDB**	ASTM D 2837	0	Unspecified
Carbon black	ASTM D 1603	C	>2%

Generally, HDPE products are flexible, corrosion and chemical resistant, lightweight and have great durability. In term of flexibility, HDPE materials can very high elongation before breaking. Apart from being harder and more opaque, HDPE also can withstand somewhat higher temperature up to 120°c for short periods and 100°c continuously. On the negative side, HDPE has a high thermal expansion and tends to fail under mechanical and thermal stress, making it easily subject to stress cracking.

HDPE can be divided into Virgin High Density Polyethylene (VHDPE) and recycled High Density Polyethylene (RHDPE). Experiments showed that VHDPE has a high crystallization rates than RHDPE which is indicted by their significant larger peak heat flow during cooling run. The peak heat flow rate is reduced by use of fibres in the both type of resins, (Fei Yao, Qingling, Yong, 2008).

2.6 TESTING

2.6.1 Flexure

Flexural properties as determined by these test methods are especially useful for quality control and specification purposes. These test method cover the determination of flexure properties of unreinforced and reinforced plastics, including high modulus composites and electrical insulating materials in the form of rectangular bar molded directly or both rigid and semi-rigid material,(ASTM D790 – 10).

The Nordson DAGE 500pluss tester provides the ability to perform 3 and 4 point flexure text. 3 point flexure test produces its peak stress at the specimen mid-point with reduced stress elsewhere and the 4 points flexure test produces peak stress along an extended region of the specimen hence exposing a larger length of the specimen with more potential for defects and flaws to be highlighted.

2.6.2 Deflection

Particularly deflections and vibration are becoming increasingly important with the move towards longer span, more slender, reinforced concrete slab structure. In order to satisfy the serviceability of slab, AS 3600-2009 states that design checks shall be carried out for all appropriate service condition to ensure the structure will perform in manner appropriate for its intended function and purpose. However, three options when it comes to determining the deflection of a slab or beam; to undertake a detailed design, utilise the provided simplified approach or to meet deemed to comply requirements, (AS 3600-2009).

According to Varma and Pendharkar, 2010 presented a rational approach to estimating short-term deflection in two-way slabs. The approach has been designated as Equivalent Load Method. The deflection calculated by this approach is found to be more comparable with experimental values.

2.7 CONCLUSION

This chapter summarize the previous literature by someone in considering the critical points of current knowledge including substantive finding, as well as theoretical and methodological contributions to a particular topic and also can be a secondary source for doing an experimental work. This chapter, include the use of High Density Polyethylene (HDPE) as a replacement slab has basically done from previous research. The information from this chapter can be interpreted as a review of an abstract completion and will help to complete the research and achieve the objective of this project. Next chapter will explain about methodology of this project.

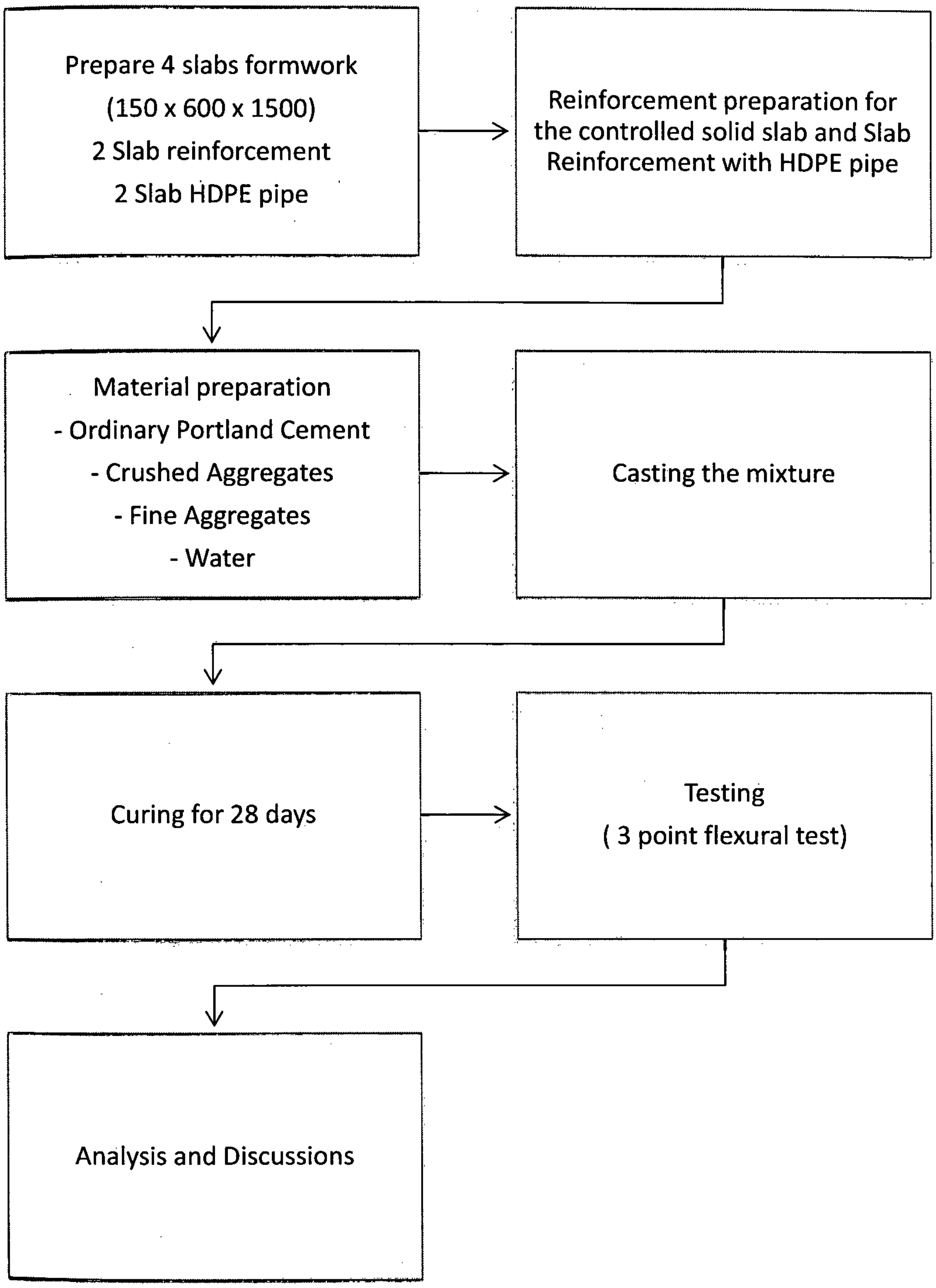
CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In chapter three will cover the project process flow and explained how the study being carried through. This chapter, explanation about the materials used, the research planning and the testing conducted to determine the characteristic of Slab Reinforced with HDPE pipe (SREHP). This chapter also will give a clear point of view about the research and clearly shows how the objective of this research achieved. At the early stage, the data and the literature review were collected from the previous study.The source of the study such as books, journals, magazine, research papers, articles, symposium papers and internet.The discussion conducted in order to improve and gain the knowledge and information regarding the scope of the research. There are several tests need to be carried out such as flexure test, tensile test and deflection test.

3.2 FLOW CHART



3.3 MATERIAL AND PREPARATION

Four samples consist of 2 slab reinforcement and 2 slab HDPE pipe are used for laboratory testing. 1 concrete cube is used for each different type of slab; control slab reinforcement and slab HDPE pipe. Concrete cube are used to determine the grade of concrete G30 to use in slab. The entire sample used for flexure test, deflection test and tensile test. All samples are according to practice size; 1500mm x 600mm x 150mm for slab and 150mm x 150mm for concrete cube.

3.3.1 Concrete

Concrete is a composite construction material made primarily with aggregate, cement, and water. There are many formulations of concrete which provide varied properties and grade.

3.3.1.1 Ordinary Portland Cement (O.P.C)

The type of cement that used for this project is Ordinary Portland Cement (OPC) with grade of G30 that following the specification British Standard. Ordinary Portland Cement made from blending iron, silicone, aluminium and calcium. All these materials were extracted from one or more of the sources such as limestone, chalk, silica sand, iron ore, shells, shale, clay and the last one is blast furnace slag. Table 3.0 shows the constituent of the Ordinary Portland Cement used.

Table 3.0: Constituents of Portland cement

Cement	**Mass (%)**
Calcium Oxide, CaO	61-67 %
Silicon Dioxide, SiO2	19-23 %
Aluminium Oxide, Al2O3	2.5-6 %
Ferric Oxide, Fe2O3	0-6 %
Sulphate, S	1.5-4.5 %