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Experimental Investigation of Strength Characteristics on Beams using Plastic

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Abstract: One of the major challenges of our present society for our protection of our environment. In recent years, there has been a dramatic increase in investigating ways in which mixed plastics can be recycled or reclaimed for reprocessing. There are usually two methodologies when dealing with recycling mixed plastics that consist of different polymers. One method is to grind up the mixed material and then to add in a small amount of this regrind back into the process of making new parts of products. The other method is to separate the mixed polymers, in order to reobtain the pure components. It serves natural resources and reduces the space required for the landfill disposal. This paper represents the experimental results of replacement of concrete by using plastic in order to increase the flexural strength of beam. The results of an extensive experimental program aimed at examining the strength of plastic reported in this paper.

1.0 Introduction

1.1 General

Plastic is a material consisting of any of wide range of synthetic or semi-synthetic organics that are mallelable and can be moulded into solid objects of diverse shapes .Plastics are typically organic polymers of high molecular mass, but they often contain other substance. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plasticity is the natural property of all materials that are able to irreversibly deform without breaking, but this occurs to such a degree with this class of mouldable polymers that their name is emphasis on this ability.

Due to their relatively low cost, ease of manufacture, versatility and imperviousness to water, plastics are used in an enormous and expanding range of products, from paper clips to spaceships. They have already displaced many materials such as wood, stone, horn, bone, leather, paper, metal glass and ceramic in most of their former uses. In developed countries, about one third of plastic is used in packaging and other third in building such as piping used in plumbing or vinyl sliding. Other uses include automobiles (upto 20% plastic), furniture and toys. In the developing world, the ratio may be different – for example, reportedly 42% of India's consumption is used in packaging. Plastics have many uses in the medical field as well, to include polymer implants, however the field of plastic surgery is not named for use of plastic material, but rather the more generic meaning of the word plasticity in regards to the reshaping of flesh.

2.0 Literature Survey

2.1 Jones Net.al. International periodical press Rotterdam Netherlands

A review is made on which has been published on the theoretical and experimental plastic behaviour of laterally loaded beams and rectangular plates. This article focuses the attention on these particular structures since they are used extensively in marine vehicles and structural designs in general. It is well known that investigations into the static dynamic inelastic behaviour of structures are simplified considerably when elastic effects can be disregarded. It is shown herein that quite reasonable agreement can be achieved between experimental results and the corresponding rigid –plastic predictions provided that both the influence of finite lateral deflections, or geometry changes, and the effect of material strain-rate sensitivity are retained when approximate. The results of some recent studies are also reported which indicate that extremely small in-plane displacement at the supports of the beams and plates can influence significantly the structural response.

2.2 Stanislaw Dorosz and Antoni Sawczu, 1981

The author influenced plastic zone on deflections of plastic beams is studied. Methods for displacement evaluation and bounding are proposed employing the Betti reciprocity theorem when distortion field due to plastic deformation appears in finite zones. Comparisons are made with experiments under monotonic as well as variable loading.

2.3 Bartosz Miller,Poland ,June 13-17, 2010.

Single load parameters are identified on the bases of changes of known dynamic characteristic of an elastic plastic steel beam. It is also loaded by a control load in order not to involve characteristics of the initial structure. Special attention is paid to the location of measurement points to obtain accuracy of computations corresponding to possibilities of planned measurement devices. Finite element method was use for the simulation of dynamic characteristic and standard neural networks were applied for the inverse analysis. The main goal of the paper is the formulation of a new non-destructive method in the area of health monitoring of civil engineering structures.

2.4 Prinsengracht, KLPR Products, 1975

Originally Lankhorst Recycling products produced only recycled plastic poles and planks. However , over many years we have developed the necessary levels of knowledge and skills that mean we can when requested take on the responsibility for the whole process. For several local councils for instance we guided and executed the entire process from A-Z.

When a customer for instance wants to have a bridge built, certain demands concerning load bearing capacity, appearance and span have to be compiled with. Based on such preconditions we then start working. Depending on the application involved we will advice on which material to be used best. We will do the calculations, provide construction drawings and subsequently manufacture the bridge. Lankhorst has also built some very strong partnership within the construction industry and this now enables us to offer the complete package.

3.0 Types of Plastics

3.1Thermoplastics which are softened by heat and can be moulded. (Injection moulded, blow moulded or vaccum formed). Good examples are acrylic ,polypropylene, polystyrene, polythene and PVC.

3.2Thermosets which are formed by heat process but are then set (like concrete) and cannot change shape by reheating .Good examples are melamine (kitchen worktops), Bakelite (black saucepan handles), polyster and epoxy resins.

4.0 Engineering Plastics

Engineering thermoplastics are a subset of plastic material that are used in application generally requiring higher performance in the areas of heat resistance, chemical resistance, impact, fire retardancy or mechanical strength. Engineering thermoplastics are so named as they have properties in one or more areas that exhibit higher performance than commodity materials and are suitable for applications that require engineering to design parts that perform in their intended use.

5.0 Material Properties

5.1 Polyethylene:

Polyrthylene (abbreviated PE) or polyethylene (IUPAC name polyethene or poly (methylene)) is the most common plastic. The annual global production is around 80 million tones. Its primary use in packing (plastic bags, plastic films, geo-membranes, containers including bottles, etc.)Many kinds of polyethelyene are known, with most having the chemical formulae $(C_2H_4)_n$ .Thus, PE is usually a mixture of similar polymers of ethylene with various values of n.

- Polyethylene (polyethylene, polyethene, PE) is a family of similar materials categorized according to their density and molecular structure. For example:
- Ultra high molecular weight polyethylene (UHMWPE) is tough and resistant to chemicals. It is used to manufacture moving machine parts, bearing, gears, artificial joints and some bullet proof vests.
- High-density polyethylene (HDPE), recyclable plastic no.2, is commonly used as milk jugs, liquid laundry detergent bottles, outdoor furniture, margarine tubs, portable gasoline cans, water drainage pipes, grocery bags.
- Medium density polyethylene (MDPE) is used for packaging film, sacks and gas pipes and fittings.
- Low-density polyethylene(LDPE)is flexible and is used in the manufacture of squeeze bottles, milk jug caps , retail store bags and linear low-density polyethyelene (LLDPE) as stretch wrap in transporting and handling boxes of durable goods, and as the common household food covering.

5.1.2 Mechanical Properties

Polyethylene is of low strength, hardness, and rigidity but has high ductility and impact strength as well as low friction. It shows strong creep under persistent force, which can be reduced by addition of short fibres. It feels waxy when touched.

5.1.3 Thermal Properties

The usefulness of polyethylene is limited by its softening point of 80 degree Celsius. For common commercial grades of medium and high density polyethylene the melting point is typically in the range 120 – 180 degree Celsius. The melting point for average, commercial, low density polyethylene is typically 105 – 115degree Celsius. These temperature vary strongly with the type of polyethylene.

5.1.4 Chemical Properties

Polyethylene consist of non-polar, saturated, high molecular weight hydrocarbons. Therefore, its chemical behaviour is similar to paraffin. The individual macromolecules are not covalently linked. Because of their symmentric molecular structure, they tend to crystalline, overall polyethylene is crystalline. Higher crystallinity increase density and mechanical and chemical stability.

Polyethylene burns slowly with a blue flame having a yellow tip and gives off an odour of paraffin. The material continous burning on removal of the flame source and produce a drip.

5.1.5 Electrical Properties

Polyethylene is a good electrical insulator. It offers good tracking resistance, however , it becomes easily electrostatically charged.

5.2 Polypropylene

Polypropylene (PP) also known as polypropylene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., thermal underwear and carpets0, stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. An addition polymer made from the monomer propylene, it is rugged and usually resistant to many chemical solvents, bases and acids. In 2013, the global market for polypropylene was about 55 million metric tons.

5.2.1 Mechanical Properties

Polypropylene is normally tough and flexible, especially when copolymerized with ethylene. This allows polypropylene to be used as engineering plastic, competing with the materials such as acrylonitrile butadiene styrene. Polypropylene is reasonable economical. Polypropylene has good resistance to fatigue.

Young's modulus is between 1300-1800N/mm^2

5.2.2 Thermal Properties

The melting point of polypropylene occurs at a range, so a melting point is determined by finding the highest temperature of a differential scanning calorimeter chart. Perfectly isotactic PP has a melting point of 171 degree Celsius. Commercial isotactic PP has a melting point that ranges from 160-166 degree Celsius , depending on a tactic material and crystallinity. Syndiotactic PP with a crystallinity of 30% has a melting point of 130 degree Celsius. Below 0 degree Celsius , PP becomes brittle.

The thermal expansion of polypropylene is very large, but somewhat less than that of polyethylene.

5.2.3 Chemical Properties

Polypropylene is at room temperature resistant to fats and almost all organic solvents, apart from strong oxidants. Non-oxidizing acids and bases can be stored in containers made of PP. at elevated temperature, PP can be solved in of low polarity solvents. Due to the tertiary carbon atom PP is chemically less resistant than PE.

Most commercial polypropylene is isotactic and has an intermediate level of crystallinity between that of low density polyethylene (LDPE) and high density polyethylene. Isotactic and a tactic polypropylene is soluble in P-xylene at 140degeree Celsius. Isotactic precipitates when the solution is cooled to 25 degree Celsius and atactic portion remains soluble in P-xylene.

6.0 Reinforcement

6.1 Details of Size And Reinforcement of Beam

Size of the beam:700mmx 150mm x 150mm
Clear cover: 25mm[1,2]
Main rods :4#-12mmØ
Stirrups:6#-8mmØ@10mm c/c

Materials:

(i)Thermoplastics (polyethylene,polypropylene)
(ii)steel rods

7.0 Injection Moulding

Shape forming process in which molten metal or plastic is injected into aluminium, ceramic or steel moulds(shape like the end product) and squeezed under high pressure. Injection moulding ois employed mainly in the production of solid objects[3,4,5].

Injection moulding is the most commonly used manufacturing process for the fabrication of plastic bags. A wide variety of products ar manufactured using injection moulding which vary greatly in their size, complexity and application. The injection moulding process requires the use of an injection moulding machine, raw plastic materials and a mould. The plastic is melted in the injection moulding machine and then injected into the mould, where it cools and solidifies in to the final part.

Injection moulding is used to produce thin walled plastic parts for a wide variety of applications, one of the most common being plastic housings. Plastic housing is a thin walled enclosure, often requiring many ribs and bosses on the interior. These housing are used in variety of products including household appliances, consumer electronics, power tools and as automotive dash boards. Other common thin walled products include different types of open containers such as buckets. Injection moulding is also used to produce several everyday items such as tooth brushes or small plastic toys. Many medical devices, including valves syringes are manufactured using injection moulding as well.

The process cycle for injection moulding is very short, typically between 2 seconds and 2 minutes and consists of the following four stages.

1. Clamping
2. Injection
3. Cooling
4. Ejection

Most polymers may be used including all thermoplastics, some thermosets and some elastomers. When these materials are used in the injection moulding process, their raw form is usually small pellets or fine powder. Also, colorants may be added in the process to control the colour of the final part. The selection of a material for creating injection moulded parts is not solely based upon the decide characteristic of the final part. Where each material has different properties that will effect parameters used in processing these materials. Each materials require a different set of processing parameters in the injection moulding process, including the injection temperature, injection pressure, mould temperature, ejection temperature and cycle time.

8.0TESTING

- Prepare the test specimen by filling plastic and concrete into the mould. Tamp it well so that it gets uniformly distributed.
- The specimen is allowed to cool
- The specimen shall be placed in the machine at right angles to the rollers. For moulded specimens the mould filling direction shall be normal to the direction of loading.
- The load shall be applied.

Table 1

S.No	Sample	Load P(kN)	Support length	Breadth B	Depth D	Flexural strength f_b (N/mm^2)
1	Concrete	130	700	150	150	19.6
2	Polypropylene	200	700	150	150	31.1
3	Polyethylene	210	700	150	150	33.6

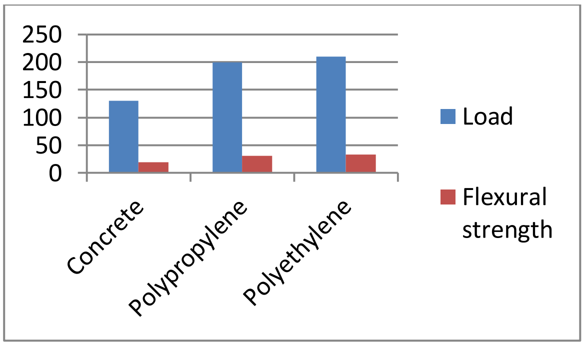

Fig 1.

9.0 Conclusion

- In this study, there are two types of beam specimens casted with polyethylene and polypropylene and their flexural strength was tested and the analysis is reported.
- The non-bio degradable plastic waste is used to substitute concrete and the flexural strength of plastic beams casted was tested and compared with steel reinforced concrete.

- Since the compression strength of plastic is nearly equal to M10 grade concrete, such concrete can be replaced by plastic.
- The flexural strength of plastic beam is higher than that of concrete beam.
- Hence, while comparing the experimental plastic beam attains an average of ten times of flexural strength than that of concrete beam.
- Based on the results, plastic beam can be used in landing slabs, bridges, buildings etc.

10.0 References

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2. ISO 178:2010 Plastics determination of flexural properties
3. IS 458-1:1985 Plastic determination of stiffness in torsion of flexible members
4. ISO 604:2002 Determination of compressive properties
5. ISO 15114:2014 Fiber reinforced plastic composites. Determination of mode II fractures resistance for unidirectionally reinforced materials.

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