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# Innovative use of Light Weight Fiber Reinforced Concrete as 'Concrete Car Bumper'

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**Abstract:** Nowadays, in order to cope up with the fast moving world, it has become essential to make efficient use of the available transportation mediums. There are a number of transportation techniques which make our life easier. One of the most important transportation medium is the road transportation which primarily uses motor cars for the same. One of the primary concerns in using motor cars is to ensure safety. In case a collision, usually the effects primarily occur on the front and rear side. In order to reduce the effects due to collisions, motors cars are provided with bumpers. The bumpers associated with cars are supposed to minimize the effect of collision ensuring minimum cost overrun. In earlier times, the materials that were used for making car bumpers were steel, but nowadays they are replaced by plastic and fiber such that they provide better looks to the car. But as a result of this change, there is subsequent change in the strength against collision possessed by the car bumpers and moreover the cost of repairs has also a considerable hike. Considering these facts a comprehensive study has been conducted on using 'Lightweight Fiber Reinforced Concrete' in order to investigate whether it could be used as an alternative for the respective fiber material. In order for the same, literature reviews of the papers associated with the topic were carried out. The study on the corresponding papers indicated a positive view towards the topic.

***Keywords:*** *fiber reinforced light weight concrete, bumper, polymer fiber*

## 1. Introduction

As it is clearly known, in this modern era, life without vehicles has become a difficult situation. In order to cope up with this fast moving world we will have to make use of the transportation medium. The most mainly and cheaply used transporting medium is the road transport system of which motor cars are the prominently used ones. One of the major components of cars is the bumper. A bumper is a structure attached or integrated to the front and rear of an automobile to absorb impact in a minor collision, ideally minimizing repair costs. In earlier times, the materials that were used for making car bumpers were steel, but nowadays they are replaced by plastic and fiber. The light weight concrete is that particular concrete with an in-place density (unit weight) on the order of 90 to 115 lb / ft³ (1440 to 1840 kg/m³) compared to normal weight concrete a density in the range of 140 to 150 lb/ft³ (2240 to 2400 kg/m³). The addition of polymer fibers to the light weight concrete will result in subsequent increase the strength of the concrete. Reinforcing the concrete will increase the stiffness and binding strength of concrete which will ensure less damage for the concrete on suffering impacts.

## 2. Objectives

The main aim of this thesis is can be listed as given below

a. To reveal the importance of Fiber reinforced light weight concrete
b. To reveal problems involved in using the conventional fiber bumper
c. To study how efficiently we could make use of the 'Light Weight Fiber Reinforced Concrete' bumper material as an alternative for the conventional materials
d. To make a comparative study between the properties of both fiber and concrete bumper
e. To obtain the most efficient and economical practise among both

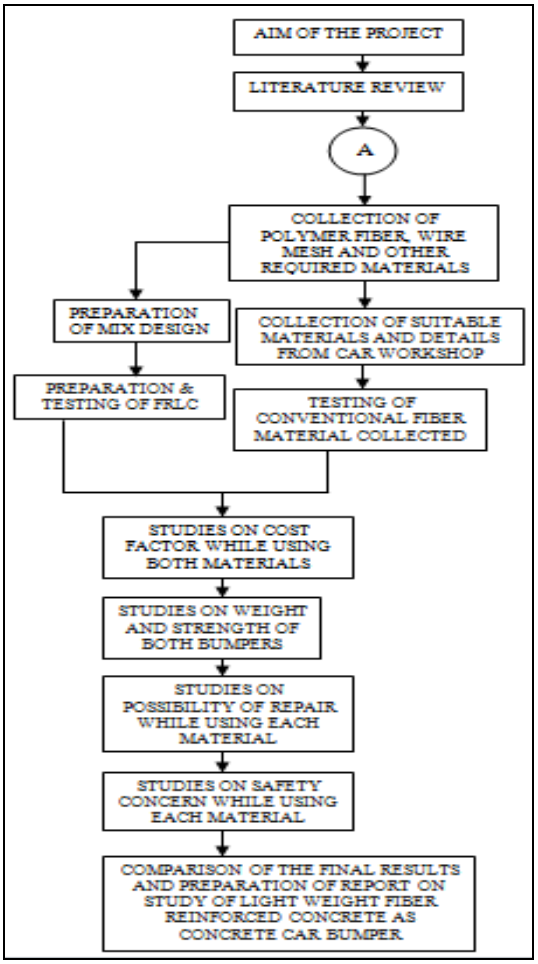
## 3. Scope

One of the primary concerns in using motor cars is to ensure safety. The entire car will be made in such a way that the safety of the persons using will be ensured. In case a collision, usually the effects primarily occur on the front and rear side. In order to reduce the effects due to collisions, bumpers are provided. The bumpers associated with cars are supposed to minimize the effect of collision ensuring minimum cost overrun. In earlier times, the materials that were used for making car bumpers were steel, but nowadays they are replaced by plastic and fiber such that they provide better look to the car. But as a result of this change, there is subsequent change in the strength against collision possessed by the car bumpers and moreover the cost of repairs has also a considerable hike. While we go for fibers, the problem is that the required impact strength is not achieved and also if it suffers any collision, we are not able to repair the fiber material, therefore we have to go for replacing it which will result in an increase in

the cost. By using the 'Light Weight Fiber Reinforced Concrete', we would be able to obtain the better looks just like we obtain while we use the fiber material with a much better impact strength. Also while we use the 'Light Weight Fiber Reinforced Concrete' material for making the car bumber, we are also provided with the option of repairing the material in case of any damage caused by collision or other effects.

## 4. Methodology

- The first step in the methodology is the collection of all the suitable materials. Since we have to use fibers for making FRLC, the polymer fibers has to be collected firstly and then the reinforcing mesh should be collected. Along with these, the conventional materials which are required for making concrete should be also collected.
- In order to carry out the testing of the light weight fiber reinforced concrete, we will have to first prepare a mix design for making the particular concrete.
- After obtaining the mix design for the concrete, we could make use of that mix design in order to prepare the fiber reinforced light weight concrete cubes which should be tested for the strength values
- Necessary details and study should be done from experts, also the samples of the presently used materials should be obtained. In order for that a car workshop has to be visited. The details about the materials of construction, strength of materials, safety, incurred cost, weight of material, impact resistance, reparability etc. of the presently used materials could be obtained from the workshops
- After knowing in detail about the fiber material, the collected sample of the fiber from the car workshops could be tested. The fiber material could be subjected to compression testing to know the resistance to breakage possessed by the material.
- From the observations that are being made by conducting the tests mentioned above, we could make a comparative study on each factor that are associated with the bumper while using the fiber material as well as while using the light weight fiber reinforced concrete material like cost, weight, strength, possibility of repair, safety concerns
- From all the tests and comparative studies mentioned before, a clear cut idea about the advantages, disadvantages and possibilities of usage of the light weight fiber reinforced concrete could be made. Also with the above statistics, a comparative study between fiber bumper and light weight fiber reinforced concrete bumper could be made from which we could understand, the usage of which of the above type of bumpers will provide us with better safety and economical cost.
- With all the information obtained, a report on study of the usage of light weight fiber reinforced concrete as concrete car bumper could be made possible. Also the comparative study between the advantages of using light weight concrete bumper over the conventional fiber bumper could also be studied




## 5. Theories and Analysis

### 5.1 Mix Design

The Mix design of m25 fiber reinforced light weight concrete is as given below.

TARGET MEAN STRENGTH = 25+ 1.65X4 =31.6 N/mm² (1)

SELECTION OF WATER CEMENT RATIO (2)

Water cement ratio =0.4
Quantity of water = 186 l/m³

For 100mm slump,

Quantity of water = 186 + 2x3% of 186 = 197 l/m³

DETERMINATION OF CEMENT CONTENT (3)

Water cement ratio =0.4
W/C = 0.4
C = 197/0.4 = 490 Kg

From IS 456, maximum quantity of cement added per $m^3$ = 450kg

Therefore, C = 450Kg

(4) DETERMINATION OF FINE AND COARSE AGGREGATE CONTENT

For 20mm aggregate, Zone 1,
Coarse/total aggregate = 0.6

Since W=0.4

Coarse/total aggregate = 0.6 + 2x0.01 = 0.62

Therefore, fine aggregate/coarse aggregate = 1-0.62 =0.38

(5) MIX CALCULATIONS

Volume of cement = weight of cement 1 $m^3$/ (specific gravity x 1000) = 450/ (3.15 x 1000) = 0.143 $m^3$

Volume of water = 197/(1x1000) = 0.197 $m^3$

Volume of aggregate = 1-(0.143+0.197) = 0.661 $m^3$

Quantity of fine aggregate = 38% of 0.661 x specific gravity of fine aggregate x 1000 = 0.38 x 0.661 x 2.65 x1000 = 665.63 Kg

Quantity of coarse aggregate = .62 x 0.661 x 2.68 x 1000 = 1098.32Kg

Quantity of polymer fiber = 0.6% by weight of cement = 0.006 x 450 = 2.7Kg

Therefore cement: water: fine aggregate: coarse aggregate = 450: 197: 665.63 : 1098.32 = 1 : 0.4 : 1.4 : 2.4

### 5.2 Visiting Car Company

One of the main parts associated with this thesis is to have a detailed knowledge about the presently used technology. Necessary details and study should be done from experts; also the samples of the presently used materials should be obtained. In order for that a car workshop has to be visited. The details about the materials of construction, strength of materials, safety, incurred cost, weight of material, impact resistance, reparability etc. of the presently used materials could be obtained from the workshops. Also collection of the material samples from the car workshops which are presently being used may be useful for making further testing on it to know in detail about the properties of the material

### 5.3 Lab Tests

After obtaining the mix design for the concrete, we could make use of that mix design in order to prepare the fiber reinforced light weight concrete cubes which should be tested for the compressive strength with the help of a UTM. A point that is to be noted while preparing the concrete is the addition of right amount of polymer fibers. The prepared cubes should be properly cured and should be tested after 28 days to compressive strength value of the concrete. In the case of concrete bumper, the term compressive strength represents the maximum gradually applied weight that the bumper can take before it gets damaged or cracked. It symbolizes the effect of the car bumper on gradually moving contact on any type of obstruction.

After knowing in detail about the fiber material, the collected sample of the fiber from the car workshops could be tested. Further testing would help us to know in detail about the properties or to ensure the details obtained from the car workshop. The fiber material could be subjected to compression testing to know the resistance to breakage possessed by the material. This compression testing symbolizes the effect of the fiber car bumper on gradually moving contact on any type of obstruction. In the case of fiber material, the fiber material will be categorized as a waste irreparable material once it gets even a minor crack. So the compressive strength of the fiber car bumper will be the maximum impact that it could handle, the impact resistance value which we will test and find out will be much lesser than the impact resistance. The impact resistance symbolizes the effect of the car bumper on sudden moving contact on any type of obstruction. The impact resistance value will be less than compared to the compressive strength value. But as the fiber material gets useless with even a minor damage, the impact resistance will be the maximum permissible value of collision that could be suffered by the fiber material. But in case on light weight fiber reinforced concrete, the concrete material could be repaired. So the compressive strength value which will be higher than the impact resistance value will be considered as the maximum permissible value of collision that could be suffered by the concrete material in case of collisions.

## 6. Results and Discussion

### 6.1 Strength

The strength consideration of the bumper material includes the compressive, tensile and impact strength. As per the details collected, the compressive strength of fiber material is 9 $N/mm^2$ and tensile strength is 2 $N/mm^2$. The values obtained by testing the compressive and tensile strength of fiber reinforced light weight concrete is given below

***Table 1*** *- 28 Day compressive strength test*

| % of LWA | Water ($kg/m^3$) | Cement ($kg/m^3$) | Fine aggregate ($kg/m^3$) | LW fine aggregate ($kg/m^3$) | Coarse aggregate ($kg/m^3$) | 28- day compressive strength ($N/mm^2$) |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | 197 | 450 | 606 | 60 | 1098 | 19.6 |
| 20 | 197 | 450 | 546 | 120 | 1098 | 17.1 |
| 50 | 197 | 450 | 333 | 333 | 1098 | 9.70 |
| 100 | 197 | 450 | - | 666 | 1098 | 7.64 |

***Table 2** – Split Tensile Strength Results*

| % of LWA | Water (kg/m³) | Cement (kg/m³) | Fine aggregate (kg/m³) | LW fine aggregate (kg/m³) | Coarse aggregate (kg/m³) | 28- day splitting tensile strength(N/mm²) |
|---|---|---|---|---|---|---|
| 10 | 197 | 450 | 606 | 60 | 1098 | 2.40 |
| 20 | 197 | 450 | 546 | 120 | 1098 | 1.82 |
| 50 | 197 | 450 | 333 | 333 | 1098 | 1.33 |
| 100 | 197 | 450 | - | 666 | 1098 | 0.18 |

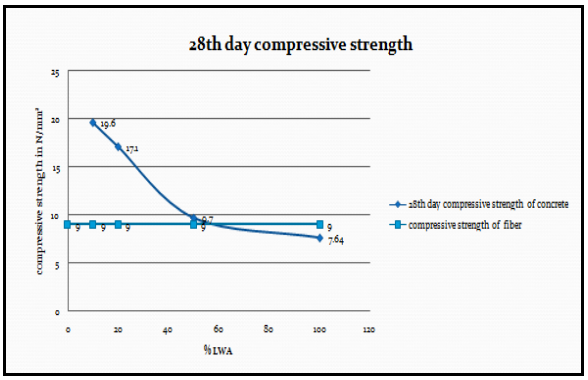



***Figure 1:** Variation of compressive strength*

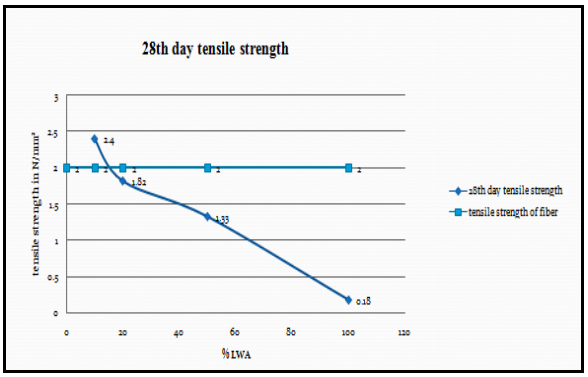



***Figure 2:** Variation of tensile strength*

From the above studies, it is clear that even with 58% replaced with light weight concrete, the compressive strength obtained will be nearly same as that of fiber bumper's compressive strength and nearly the same occurs in the case of tensile strength also for a replacement of about 18%. On a whole, it could be finalized that a 15% replacement of fine aggregate with vermiculate will obtain us concrete with same strength properties that of fiber bumper.

### 6.2 Weight

The weight of the fiber bumper as per the details obtained from the car workshop is about 8-10kg. The weight of the concrete car bumper will be the total weight of constituents of concrete. According to the tabulations made above, the weight of the concrete car bumper will be around 20 kg, but the introduction of cidonolite as fine aggregate will increase the volume of concrete, thereby decrease in weight of concrete. In case of concrete, usage of cidonolite increases the volume of concrete, thereby we obtain less weight for the same volume. In case of 100% replacement of fine aggregate, the weight loss was about 0.5 of weight, so in the case of 15% replacement, the weight loss is about 0.075 of the weight of concrete. Also about 40% of the bumper is devoid of fiber material as we have give provisions for fans, coolers, spark lights etc, so the area should be excluded. Considering this,

Total weight for then bumper dimensions = 20 Kg

Weight loss due to use of cidonolite = 0.075 x 20 = 1.5 Kg

Weight of light weight concrete = 20 – 1.5= 18.5 Kg

Area of perforations in concrete = 40 x 18.5/100 = 7.4 Kg

Weight of concrete bumper = 18.5 – 7.4 = 11.1 Kg

The usual dimensions of car bumper are 3.1 m X 0.6m X 0.002m. The width of the bumper is comparatively very less, even though much space is freely available in between the bumper and other parts is that even if we increase the width the fiber bumper cannot increase its strength and in case of any damage, the replacement cost will be also high. But in case of concrete bumper, since repairing the concrete is possible, we can have an increased width of 0.005m, therefore the dimensions will be 3.1 m X 0.6m X 0.005m. although the weight of concrete bumper is above the considerable ranger, it is due to the extra width provided with concrete.

### 6.3 Cost

From the observations that are being made by conducting the tests mentioned above, we could make a comparative study on each factor that are associated with the bumper while using the fiber material as well as while using the light weight fiber reinforced concrete material. One of the primary factors in it will be the cost.

As per the details obtained from the car company, the cost of a fiber car bumper varies from about Rs.8000 to Rs.15000. This variation in cost depends upon and the model and type of cars

The dimensions of car bumpers are 3.1m x0.6m x0.005 m and cost of the concrete car bumper will be the cost of the components required to make the concrete. Here the cost of fiber bumper varies depending upon the amount of light weight material added. According to this dimensions

Amount of cement = 4 Kg

Amount of fine aggregate = 4.92 kg
Amount of coarse aggregate = 10 kg
Amount of lightweight aggregate = 1.08 kg
Amount of fiber = 0.8kg
Amount of reinforcing SS mesh` = 3.1m X 0.6m

Cost will be about Rs. 600

Considering the miscellaneous expenses and labour charges also, the cost of concrete bumper will be less than Rs.1500, which shows that the cost of fiber reinforced concrete car bumper will be considerably very low compared to conventional fiber bumpers

### 6.4 Possibility of Repair

For fiber car bumper, there is no repair cost as there is no repair possible. So in case of repairs, the cost incurred will be the same as installing a new a bumper. The cost of installing the concrete car bumper will include the cost of the ingredients for making the concrete car bumper such as cement, aggregates, polymer fiber, wire mesh etc. For concrete car bumper, repairs are possible, so there will be repair costs. The repair cost will be comparatively less than installing a new bumper. But there will be a slight cost hike while we consider curing. Curing cannot be done through after repairing the material because for that the vehicle has to be kept at workshop for days. So in order to avoid time lag, we can go for internal curing using plasticizers which will induce a slight cost hike. The possibilities of repair in case of different damages while using both the materials is listed below

***Table 3** -Possibilities in repairing bumpers*

| Damage | Fiber bumper | Concrete bumper |
|---|---|---|
| Scratch | X | √ |
| Minor clash | X | √ |
| Major accidents | X | √ |

### 6.5 Safety Concern

The next important study that has to be done is on the safety concerns while using each material. We have to ensure the safety of the vehicles and passengers inside the car which will be decided by the effect on the bumper that is being used. The safety of the bumper, which means the safety of the car, depends on the resistance to collision of each of the materials. The study on the impact resistance and compressive strength of each material will provide a much better view on the strength of the bumper to withstand collisions, thereby ensuring the safety of the car. Safety concern in car bumpers deals with and defines the safety of passengers and interior parts of car. According to the study, for the same cost, concrete provides us with bumpers with considerably very high strength compared to the fiber bumper. Concrete bumper provides us with enhanced protection with high strength and less cost with an almost equal weight compared to fiber bumper which also provides us with the provision to repair the material in case of damage. The following table shows which of the above two type of bumper prove to be efficient for each property as per the study

***Table 4:** Final report*

| Property | Concrete/fiber/both |
|---|---|
| Strength | Concrete |
| Weight | Both equally efficient |
| Cost | Concrete |
| Possibility of repair | Concrete |
| Safety | Concrete |

## 7. Conclusions and future work

- Thus from the study, it is being observed that usage of fiber reinforced light weight concrete is efficient and economical.
- Considering the properties like strength, cost, possibility of repair etc, the fiber reinforced light weight concrete could be used as a very suitable replacement for the conventional fiber materials
- The only property which showed a negative impact was the weight of the concrete bumper, although is not considerably very high
- Also maintaining the width of car bumper to the conventional bumper dimensions, will sort out the problems arising due to weight of bumper.
- Introduction of this idea of FRLC bumpers could provide with much better results than the conventional fiber bumper while considering most of its important properties and is proved to be an efficient idea which could be practiced in near future which could make some health changes in civil and automobile industries.
- Further tests has to be done in order to study the behaviour of concrete material and fiber material on a sudden impact

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