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An Experimental Investigation on Concrete Beam with Tension Zone Replaced by Shredded Rubber Tyre Waste

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***Abstract:** The Bubble Deck technology developed in Europe makes use of high-density polyethylene hollow spheres to replace the ineffective concrete in the Centre of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. This method is used in the concrete floor system. Concrete is good in compression and hence is more useful in the compression region than in the tension region. The reduction in concrete can be done by replacing the tension zone concrete. Keeping the same idea in mind, an attempt has been made to find out the effectiveness of plastic bubbles by replacing concrete in the tension zone with shredded waste rubber tyre mould.*

I. INTRODUCTION

World population is increasing day by day in rapid rate, due to this there is lift up in the demand for safe and aesthetic infrastructural facilities. It's the human necessities which tend to development of innovative methods in construction field. As population and demand raise parallel to each other and supply fails to reach the targets there occurs an imbalance. This idea of population, demand and supply when applied in construction field one can observe the conflict that exist between nature and infrastructural development.

It is an inevitable fact that even if whole world is concerned with environmental health and safety one cannot deny the fact that directly or indirectly we all are becoming prey of our own desires. Excess usage of natural resources is hindering the source quality and quantity further causing imbalance in ecosystem.

The by-products obtained during the refining process of petroleum are used for manufacturing of tires. The main problem of tires after usage is the dumping process. This has become one of the major problem now a day both locally and globally. When the tires are burnt in the open atmosphere there will be gases released which are toxic. These gases not only affect air but can dissolve in water is improper or unscientific method of disposal, due to this scientist all over the world and economic activists are giving more importance to counter this problem.

One of the useful properties of the tires is its high resistance to fatigue. Hence we can use this property of tires to substitute some amount in concrete to carry loads during its service period. Tires are made up of sheets of elastomers which are diagonally reinforced with steel fibers and threads.

A. Scope and Significance

Beam is one of the major structural members in any construction. They transfer the load from slab to the column. Reinforced concrete beams are a composite material containing concrete and steel reinforcement and is subjected to both compressive and tensile forces. Concrete is good in compression and steel is good in tension. Ordinary Portland Cement concrete (OPCC) beams have a considerable self-weight which increases the cost of construction. There is severe shortage of raw materials due to the increase in usage of concrete and hence to solve this problem many researches are carried on for replacing concrete with different materials.

The tension zone and compression zone is divided by neutral axis in simply supported concrete beams. By applying loads, the region above neutral axis will carry compression and region below neutral axis will carry tension.

Concrete is weak in tension due to this reinforcement are placed below the neutral axis to carry tensile forces, the stresses from compression zone to tension zone are transferred by the concrete below neutral axis which is called as sacrificial concrete as shown in figure 1 (the neutral axis is at a distance of 0.42d from the top of the section where the compressive force is acting).

The bubble deck technology is used for replacing the ineffective concrete present below the neutral axis of the slab by polyethylene hollow spheres of high density which increases the efficiency of the floor by decreasing the dead weight.

The present investigation deals with the same technique in beams. Concrete is good in compression and hence is more useful in the compression region than in the tension region. The reduction in concrete can be done by replacing the tension zone concrete with shredded rubber tire waste mould.

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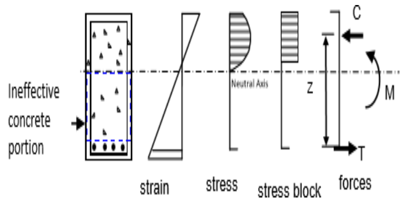

Fig 1 Ineffective concrete portion below neutral axis

Thus the sacrificial concrete replaced by shredded rubber tire waste will reduce dead weight of beam or slabs. The reduction in weight will result in reduction of cost and construction time. The new light weight section has great demand in industries and also this weight reduction will also help in sustainability of concrete.

B. Aim Of Present Study

The RCC beams carries less stresses below neutral axis, thus the concrete below neutral axis can be replaced with other lightweight materials of different types such as hollow pipes, terracotta hollow blocks and expanded polystyrene sheets etc. which reduces the dead weight. There is a change in the ultimate load carrying capacity and breaking load which is very small when compared to conventional beam. In this experiment, shredded rubber tyre wastes are used below the neutral axis to analyze its behavior.

C. Objectives

1) To determine the strength properties of ingredients used in concrete beam with shredded rubber tyre waste.
2) To analyze the behavior of concrete beam by replacement of tension zone concrete with non-conventional material like shredded rubber tyre waste under flexure.
3) To find out the comparison between the beams due to the material used and factors influencing the deflection.
4) Cost effective analysis by partial replacement of tension zone concrete in beam by the shredded rubber tyre waste in comparison with conventional concrete.
5) To verify the proposed design by comparison with those developed by other researchers and codal provisions.

D. Application

1) The rubber concrete mixture can be used in areas where vibration damping or impact resistance is more important.
2) Concrete rubber mixture can be used in areas where structural stability is not important.
3) The drainage capability and durability of playground surfaces can be improved by using waste tyre rubber.
4) In the construction of roads and railways shredded waste tyres can be used as a fillers.
5) The heat resisting property of waste tyre rubber makes it suitable for precast roofs and green building.

E. Shredded Rubber

Shredded rubber and SRWT mould was obtained from Dhanushree rubber tyres, Peenya 2nd stage , Bangalore for conducting project. The surface properties of SWRT mould were tried to be improvised by rubbing it with sand paper so that better bonding properties might be established with cement matrix. Figure 2 shows waste shredded rubber mould. The SWRT mould of length 400mm X 90mm X 60mm is placed in the tension zone below neutral axis.

Fig 2 waste shredded rubber mould.

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II. COMPRESSIVE STRENGTH OF CONCRETE CUBES

The test was carried out in accordance with IS 516 – 1999 standards conducted on concrete specimen of size 150mm x 150mm x 150mm. The OPCC specimens which are submerged in clean fresh water are taken out after 28 days for testing and kept in dry place so that the water is drained well to get better results. The load is applied to the surface other than top and the bottom surface at the cast. Load is applied on the specimen in the compression testing machine and the load is gradually applied until it fails.

The obtained compressive strength values are tabulated below

Table 1 Results of compressive strength (28 days curing)

Cube	Weight (kg)	Load (kN)	CompressiveStrength (N/mm^2)
1.	8.15	1300	57.77
2.	8.26	1150	51.11
3.	8.21	1250	55.61
	Average Compressive strength		54.83

A. *Casting Of Beams*

The test specimen is prepared by filling concrete in the mould in three layers giving 25 uniform blows each. Loading rollers and the bearing surfaces of the supports were cleaned.

UTM is use for this experiment and specimen is placed in it so that the load applied will be on the top most surface as cast in the mould along two lines which are spaced at 20cm apart. Care should to be taken as to align the axis of specimen to the axis of loading device. Packing is not done between the bearing surfaces off the specimen and rollers. Dial gauge arrangement has been done to the loading cylinder to know the deflection for the applied load. Without sudden shock load is applied continuously at the rate of 400 kg/minute. After every 1KN increment in load central deflection is noted. Until specimen failure load is applied and type of the failure is noted down. From readings obtained load vs central deflection graph is plotted.

The beams casted are tested for flexural strength using 2-point loading. From readings obtained load vs central deflection graph is plotted. Diagonal crack propagates from support region at failure as observed in Fig.4. A beam model without SWRT mould is shown in Fig 5.

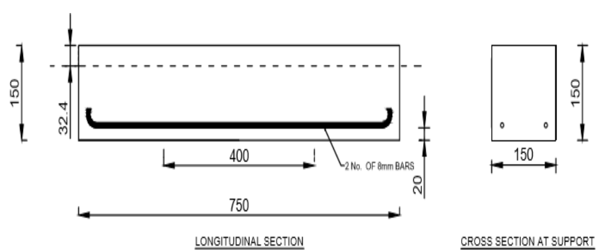

Fig. 4 Beam model without SRWT mould

Fig. 5 Beam reinforcement without SRWT mould

B. Beam With 400mm Length SRWT Mould

The replacement of tension zone concrete had been done by SRWT mould of length 40 cm placed in the central portion of the beam as shown in Fig. 6. The length of SRWT mould was chosen to be 40 cm so that a cover of 5 cm is available in tension zone on either side as two point loading is done at 60 cm. The beams are tested under 2 point loading. The failure pattern was similar to that of beam without SRWT mould with diagonal cracks appearing from the support region as shown in Fig 7.

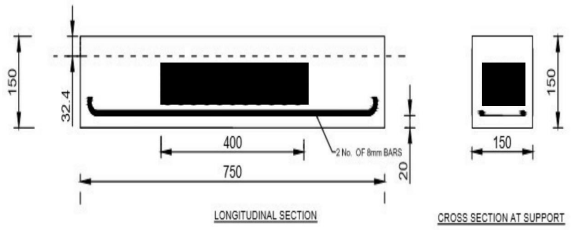

Fig. 6 Beam model with 40 cm SRWT mould

Fig. 7 flexure test on beam without SRWT mould

C. Beam With 400mm SRWT Mould and Shear Reinforcement

The replacement of tension zone concrete has been done by SRWT mould of length 40 cm placed in the central portion of the beam (as seen in Fig. 8). The length of SRWT mould was chosen to be 40 cm so that a cover of 5 cm is available in tension zone on either side as two point loading is done at 60 cm. Also, one shear link of 6 mm diameter rod at a distance of 90 mm from support is provided at either support. Beams are tested under 2 point loading. Failure is indicated by vertical cracks propagating from bottom of the beam to the top in the pure bending zone (as seen in Fig 9).

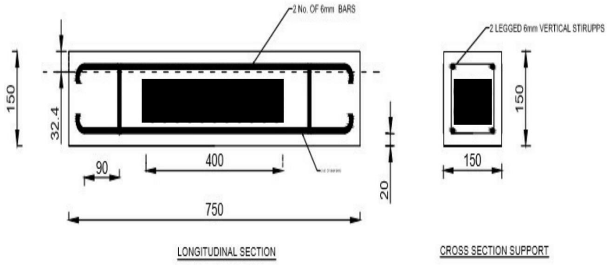

Fig.8 Beam with 40 cm SRWT mould and shear reinforcement

Fig. 9 Beam placed with 40 cm SRWT mould and shear reinforcement

Fig.10 failure pattern on beam with SRWT mesh and shear reinforcement

D. Breaking Load

The value of breaking load of beam without SRWT mould is higher than those with SRWT mould beams. The breaking load is almost the same for beams without SRWT mould and those with SRWT mould and shear reinforcement beams. Table 2 gives the breaking load of beams.

Table 2 Breaking load of beam

Specimen	Breaking load (kN)
Beam with tension reinforcement	78.6
Beam with SRWT mould	51.8
Beam without SRWT mould and shear reinforcement	89.7
Beam with SRWT mould and shear reinforcement	78.5

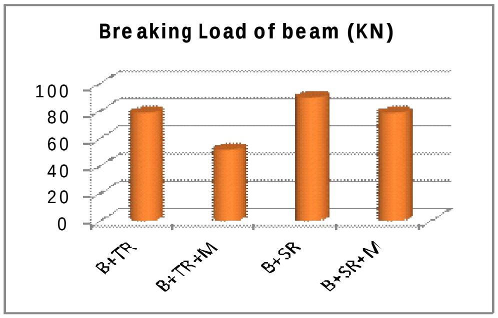

Fig. 11: breaking load of beams at 28days

E. Flexural Strength

From graphs flexural strength of beams with SRWT mould is lower than those without SRWT mould. However, when shear reinforcement has been provided along with SRWT mould, the strength has increased again to the level of beams without any SRWT mould (as seen in Table 3).

Table 3 Flexural strength of beam

	OPCC Beam Flexural strength (N/mm^2)
Beam with tension reinforcement	14.41
Beam with SRWT mould	12.3
Beam without SRWT mould and shear reinforcement	19.56
Beam with SRWT mould and shear reinforcement	17.28

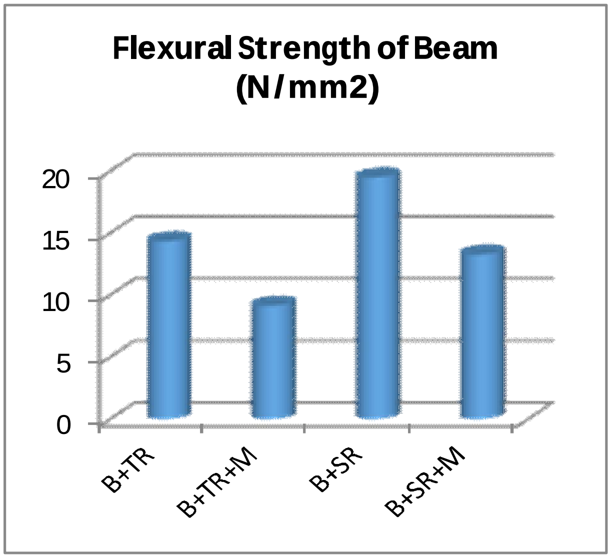

Fig12: flexural strength of beams at 28days

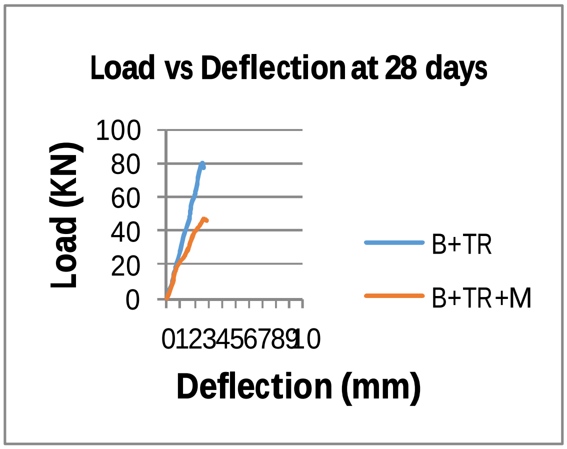

Fig 13 Load versus Central deflection graph for RCC beam and RCC beam with SRTW mould.

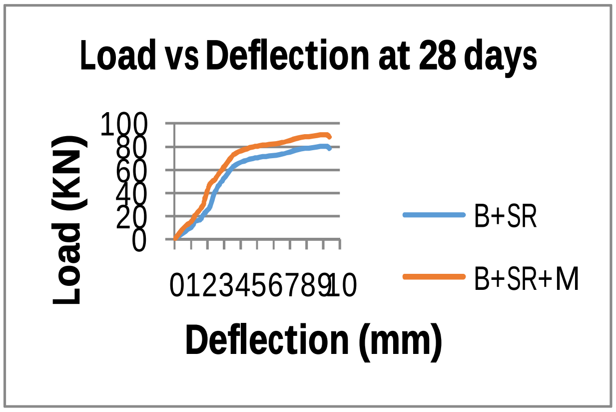

Fig 14 Load versus Central deflection graph for RCC beam with shear reinforcement and RCC beam with SRTW mould and shear reinforcement.

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F. Weight

There has been a considerable reduction in weight of beam with SRWT mould when compared to the beam without it. Here a reduction in weight up to 15.65% has been obtained between beam with and without 400mm SRWT mould (as seen in Table 4).

Table 4 Weight comparisons of beam

Specimen	Beam	
	Weight (kg)	Unit weight (kg/m^3)
Beam with tension reinforcement	42.36	2510.22
Beam with SRWT mould	35.73	2117.33
Beam without SRWT mould and shear reinforcement	43.58	2582.51
Beam with SRWT mould and shear reinforcement	38.13	2259.55

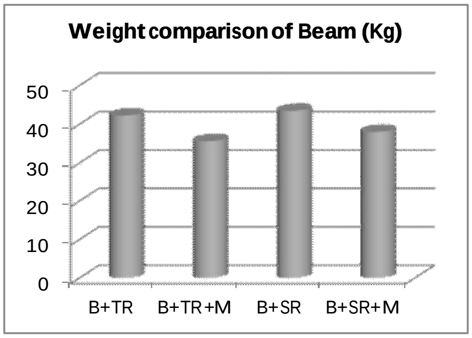

Fig. 19: weight comparison of beams

G. Cost Analysis

Table 5 Cost analysis of beam without SRWT mould

Material	Quantity /1m^3	Rs. / unit	Cost (Rs)
Water	180.3	0.5/ litre	90.15
Cement	405	7/ kg	2835
Fine aggregate	688.28	1.75/ kg	1204.49
Coarse aggregate	1117.95	1.33/ kg	1486.87
steel	24	43/kg	1032
Total			6648.51

Table 6 Cost analysis beam with SRWT mould

Material	Quantity /1m3	Rs. / unit	Cost (Rs)
Water	170.3	0.5/ litre	85.15
Cement	365	7/ kg	2555
Fine aggregate	615.28	1.75/ kg	1076.74
Coarse aggregate	901.7	1.33/ kg	1199.2
steel	24	43/kg	1032
SWRT	6	20/mould	120
Total			6068.09

III. CONCLUSIONS

Concrete beam of size 750mm x 150mm x 150mm with replacement of concrete below neutral axis with SRWT mould and shear reinforcement were tested for beams. Based on the test results, the following conclusions have been made:

1) The 28 days compressive strength for conventional concrete cubes obtained was about 54.83 MPa meeting its necessary standard requirements.

2) The replacement of tension zone concrete with SRWT mould has caused a decrease in flexural strength of beams. However, its nominal strength has been maintained for beams with SRWT mould replacement with shear reinforcement.

a) The flexural strength of beam with tension zone replaced with SRWT mould was found to be reduced by 15.12% when compared to beam with tension reinforcement only.

b) The flexural strength of beam with tension zone replaced with SRWT mould was found to be reduced by 17.12% when compared to beam with shear reinforcement only.

3) The replacement of tension zone concrete with SRWT mould has caused a increase in deflection of beams. However being in par with that of codal provisions.

a) The deflection of beam with tension zone replaced with SRWT mould was found to be increased by ________% when compared to beam with tension reinforcement only.

b) The deflection of beam with tension zone replaced with SRWT mould was found to be increased by ________% when compared to beam with shear reinforcement only.

4) It has been observed that the placement of SRWT mould in concrete beam does not require any additional time. However, accurate placement of the mould without displacement while pouring the concrete is a challenge. Another challenge is allowing for sufficient concrete to be present between lower portion of SRWT mould and tension zone reinforcement to enable maximum transfer of tensile forces from concrete to reinforcement.

5) There is considerable saving in cost up to 8% for the materials required for concrete beam with tension zone replaced by shredded rubber tyre waste.

6) About 15% by weight of concrete has been observed to be reduced without compromising on strength.

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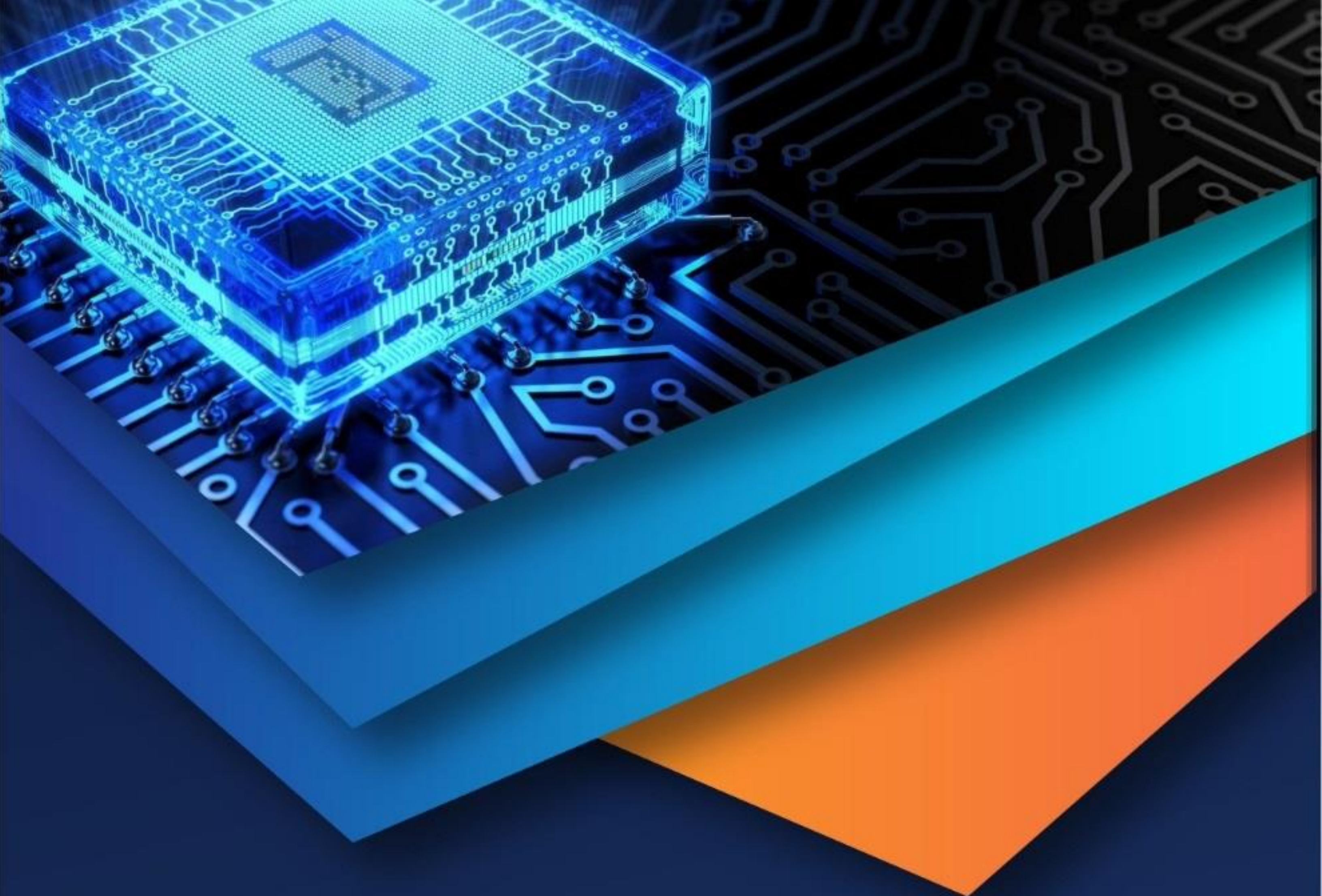

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