ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.11, pp 45-53, 2017

Seismic Resistant of Structures by Elastic Materials (Nickel titanium & crushed scrap tire rubber)

A Jayaraman*, P Naveenna, S Ruby Sounderya, N R Divyadharshini

Bannari Amman Institute of Technology, Sathyamangalam -638401,India

Abstract : A large majority of structures and bridges are made of steel and concrete. While this combination is convenient and economical, steel-concrete structures and bridges don't hold up as well in strong earthquakes (7.0 magnitude or higher). Conventional reinforced columns rely on the steel and concrete to dissipate energy during strong earthquakes, potentially creating permanent deformation and damage in the column and making the column unusable. Under earthquake loading, engineers allow for damage in column hinges to dissipate energy and prevent total bridge collapse. While that practice is widely accepted, the effects of hinge damage can interfere with disaster recovery operations and have a major economic impact on the community. We have identified several smart materials and partially or fully replacement in reinforced concrete structures & bridges. We are going to use inelastic building materials, which are most earthquake resistant. This means that, it can absorb the stress imposed by an earthquake and return to its original shape. The inelastic building materials such as crushed scrap tire rubber, Nickel titanium, or nitinol, glass and carbon fiber-reinforced polymer composites were used.
Keywords : waste-tire rubber, concrete, compression, coarse aggregate, fine aggregate.

Introduction:

Earthquake-resistant structures are structures designed to withstand earthquakes. While no structure can be entirely immune to damage from earthquakes, the goal of earthquake-resistant construction is to erect structures that fare better during seismic activity than their conventional counterparts.According to building codes, earthquake-resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the loss of life should be minimized by preventing collapse of the buildings for rare earthquakes while the loss of the functionality should be limited for more frequent ones.Currently, there are several design philosophies in earthquake engineering, making use of experimental results, computer simulations and observations from past earthquakes to offer the required performance for the seismic threat at the site of interest. Recent earthquake damage has exposed the vulnerability of existing structures to strong ground movement. The researchers are analyzing shape-memory alloys for their potential use in constructing seismic-resistant structures."Shape-memory alloys exhibit unique characteristics that you would want for earthquake-resistant building and bridge design and retrofit applications: they have the ability to dissipate significant energy without significant degradation or permanent deformation.To improve the performance of structures during earthquakes, researchers around the world have been investigating the use of "smart" materials, such as shape-memory alloys, which can bounce back after experiencing large loads. The most common shape-memory alloys are made of metal mixtures containing copper-zinc-aluminum-nickel, copper-aluminum-nickel or nickel-titanium. Potential applications of shape-memory alloys in bridge and building structures include their use in bearings, columns and beams, or connecting elements between beams and columns. But before this class of materials can be used, the effect of extreme and repetitive loads on these materials must be thoroughly examined.“For standard civil engineering materials, you can use mechanics to look at force and displacement to measure stress and strain, but for this class of shape-memory alloys that changes properties when it undergoes loading and unloading.Rubber bricks are typically made from recycled rubber, often from tires. They are manufactured in a variety of shapes and sizes, ranging from large and decorative to something closely approximating a traditional clay brick.Rubber bricks are typically used as flooring in horse stables, because they do not become slippery when wet, and their natural softness cushions horses' joints. They are also used around homes because they are very durable and require little maintenance.Waste-Tire rubber is one of the significant environmental problems worldwide. With the increase in the automobile production, huge amounts of waste tire need to be disposed. Due to the rapid depletion of available sites for waste disposal, many countries banned the disposal of waste tire rubber in landfills. Research had been in progress for long time to find alternatives to the waste tire disposal. Among these alternatives is the recycling of waste-tire rubber. Recycled waste tire rubber is a promising material in the construction industry due to its light weight, elasticity, energy absorption, sound and heat insulating properties. In this paper the density and compressive strength of concrete utilizing waster tire rubber has been investigated. Recycled waste tire rubber has been used in this study to replace the fine and coarse aggregate by weight using different percentages. The results of this paper shows that although, there was a significant reduction in the compressive strength of concrete utilizing waste tire rubber than normal concrete, concrete utilizing waste tire rubber demonstrated a ductile, plastic failure rather than brittle failure.It is recommended to test concrete with different percentage of crumb rubber ranging between (10% up to 25%) to study its effect on the concrete strength. It is recommended to test concrete with different percentage of crumb rubber with silica fume additive to overcome the significant reduction in concrete strength resulting from the replacement of sand by crumb rubber.It is recommended to use rubcrete in the production of curbs, roads, concrete blocks, and non bearing concrete wall[1].For rubberized concrete, the test results show that the addition of rubber aggregate resulted in a reduction in concrete compressive strength compared with the control concrete. This reduction increased with increasing percentage of rubber aggregate. Losses in compressive strength ranging from 6.5 % to 64.02 % were observed. The reason for the strength reduction is due to lack of adhesion at the boundaries of the rubber aggregate, soft rubber particles behave as voids in the concrete matrix.The results of the splitting tensile strength tests show that, there is a decrease in strength with increasing rubber aggregate content like the reduction observed in the compressive strength tests. However, there was a smaller reduction in splitting tensile strength as compared to the reduction in the compressive strength. The visual observation of the patterns of failure mode shows that the rubberized concrete does not exhibit typical compression failure behaviour. The control concrete shows a clean split of the sample into two halves, whereas the rubber aggregate tends to produce a less well defined failure. Moreover, the mode of failure was a gradual type rather than the brittle failure in the control concretes.A significant advantage of increase in flexural strength was achieved by limiting the replacement amount to only 10 % of the fine aggregate. In these two categories of concretes, for rubber aggregate contents of 15 and 20 % a flexural strength reduction was observed compared to the control mixes. The reduction indicates that improvements in flexural strength are limited to relatively small rubber aggregate contents. Since the tendency of the flexural strength test results are a bit different from the other strength test results due to ductile nature of rubber materials[2].The addition of light rubber crumbs and fly ash desirably decrease the density of the composite brick when compared to those commercially sold in the market. Water absorption test revealed that the produced composite brick is more efficient in minimizing water absorption. This study demonstrated that composite brick can be made using industrial wastes as substitute for aggregate and binder, with huge implication in brick concrete making [3].The light unit weight qualities of rubberized concrete may besuitable f or architectural application, false facdes, stonebaking, interior construction, in building as an earthquakeshock wave absorber, where vibration damping is requiredsuch as in foundation pads f or machinery railway station,where resistance to impact or explosion is required, such asin jersey barrier, railway buffers, bunkers and f or trenchfilling.The compressive strength of the concrete decreases about37%when 20% sand is replaced by crumb rubber. For largepercentage of crumb rubber the compressive strength gainrate is lower than that of plain concrete [4].Rubber is water repellent and resistant to alkalies and weak acids. Rubber's elasticity, toughness, im permeability, adhesiveness, and electrical resistance make it useful as an adhesive, a coating composition, a fiber, a molding compound, and an electrical insulator. In general, synthetic rubber has the following advantages over natural rubber: better aging and weathering, more resistance to oil, solvents, oxygen, ozone, and certain chemicals, and resilience over a wider temperature range. The advantages of natural rubber are less build up of heat from flexing and greater resistance to tearing when hot.Use rubber bricks to provide non-slip flooring in stables, to reduce water use in standard toilets, and as decorative pavers in home and garden settings. Rubber bricks are softer than traditional materials, so they also offer safety advantages.

II. Aim of the Study

To regain the position of the building vulnerable to earthquake of ground motion using interlocking rubber brick and Nickel-Titanium

III . Experimental Investigation

Materials Used

3.1 Nickel-Titanium

The ability of nitinol is to undergo deformation at one temperature, then recover its original, undeformed shape upon heating above its "transformation temperature". Superelasticity occurs at a narrow temperature range just above its transformation temperature; in this case, no heating is necessary to cause the undeformed shape to recover, and the material exhibits enormous elasticity, some 10-30 times that of ordinary metal show in fig .1

Ultimate Tensile Strength – The amount of tensional force required to fracture a specimen.

Ultimate Elongation – The amount a specimen deforms by stretching.

Young's Modulus – The slope of the stress-strain curve that is generated during a

Tensile strength test.

Tangent Modulus – Any point on the stress-strain curve.

Yield Point – The force at which a material will begin to deform Permanently

Nickel Titanium

Fig 1:Nickel Titanium

Table 1: Mechanical and physical properties of Nickel Titanium

Elastic modulus	75–83 GPa
Poisson's ratio	0.33
Yield strength	195–690 MPa
Melting point	1310°C
Elongation	15.5%
Appearance	Bright silver metal
Density	6.45 g/cm3 (0.233 lb/cu in)
Electrical resistivity	82×10−6 Ω·cm
Thermal conductivity	0.1 W/cm·°C
Coefficient of thermal expansion	11×10−6/°C
Heat capacity	0.077 cal / gm°C
Magnetic permeability	< 1.002

3.1.1Elasticity of Building Material

The capacity of a material to regain its initial shape and size after removal of load is known as elasticity and the material is called as elastic material. Ideally elastic materials obey Hooke's law in which stress is directly proportional to strain. Which gives modulus of elasticity as the ratio of unit stress to unit deformation. Higher the value of modulus of elasticity lower the deformations.

3.1.2 Plasticity

When the load is applied on the material, if it will undergo permanent deformation without cracking and retain this shape after the removal of load then it is said to be plastic material and this property is called as plasticity. They give resistance against bending, impact etc.

3.1.3 Brittleness

When the material is subjected to load, if it fails suddenly without causing any deformation then it is called brittle material and this property is called as brittleness.

Examples: concrete, cast-iron etc.

3.1.4Impact Strength

If a material is subjected to sudden loads and it will undergo some deformation without causing rupture is known as its impact strength. It designates the toughness of material.

3.1.5Abrasion Resistance

The loss of material due to rubbing of particles while working is called abrasion. The abrasion resistance for a material makes it durable and provided long life.

3.1.6Creep

Creep the deformation caused by constant loads for long periods. It is time dependent and occurs at very slow rate. It is almost negligible in normal conditions. But at high temperature conditions creep occur rapidly.

3.2Crushed Rubber

Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord (fluff) are removed, leaving tire rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid of cryogenics or by mechanical means, reduces the size of the particles further.Shown Fig. 2 and table 2 & 3 Crushed Rubber Characteristics and physical properties

Crushed Rubber

Fig: 2 Crushed Rubbers

Table. 2Crushed Rubber Characteristics

Mass percentage Rubber	54%
Carbon black	29%
Textile	2%
Oxidize zinc	1%
Sulphur	1%.
Additives	13%

Table 3: Physical properties of crushed rubber

Density	1600kg/m^3
Size	2.36-3.4mm
elongation	420%
Rate of steel fiber 0%	0%

3.3 Fine Aggregate

Natural sand obtained from local river source is used as fine aggregate. Before mixing, the sand was air dried and free from foreign material. The grading of fine aggregate conforms to Zone III of IS 383 – 1970 [6]. The physical properties are tabulated in Table 4 which conforms to IS: 2386- 1&3 [7].

Table 4. Physical Properties of Fine Aggregates

Physical Properties	Test Result
Size	2.36 mm
Specific Gravity	2.35
Water Absorption	0.80%

3.4 Coarse Aggregate

Crushed granite of size 10 mm was used as coarse aggregate. The physical properties of coarse aggregate are tabulated in Table 5 which conforms to IS: 2386- 1, 3&4 [7].

Table 5.Physical Properties of Coarse Aggregates

Physical Properties	Test Result
Size	10 mm
Specific Gravity	2.70
Water Absorption	0.12%
Aggregate Impact Value	11.01%

3.5Cement

43 Grade OPC conforming to IS 12269 – 1987 [8] was used. The physical properties are tabulated in Table 6.

Table 6. Physical Properties of Cement

Properties	Specific Gravity	Fineness
Value	3.06	325 m^2/kg

3.4 Water

Potable water was used for concreting and curing process as specified in IS 456 – 2000 [9].

IV Methodology

Mould of size 19x9x9mm

Bricks with a characteristic compressive strength of 20N/mm^2. Three mixes were prepared by replacing 25%, 50% weight of fine aggregate by crushed rubber(CS) and conventional was prepared as control mix without any replacement for fine aggregate. In order to study the strength and elongation comparison of crushed rubber and conventional bricks.The casted bricks are soaked in water.

V .Result and Discussion

The following testwas conducted for bricks of replacement percentage as shown in fig.3&Table. 7

Table 7: Comparison of Elongationand Strength for Bricks

Percentage replacement	Weight(kg)	deflection (mm)	Strength(N/mm^2)
conventional	4.65	0.02	19.58
25%	4.25	0.04	17.5
50%	4	0.09	16

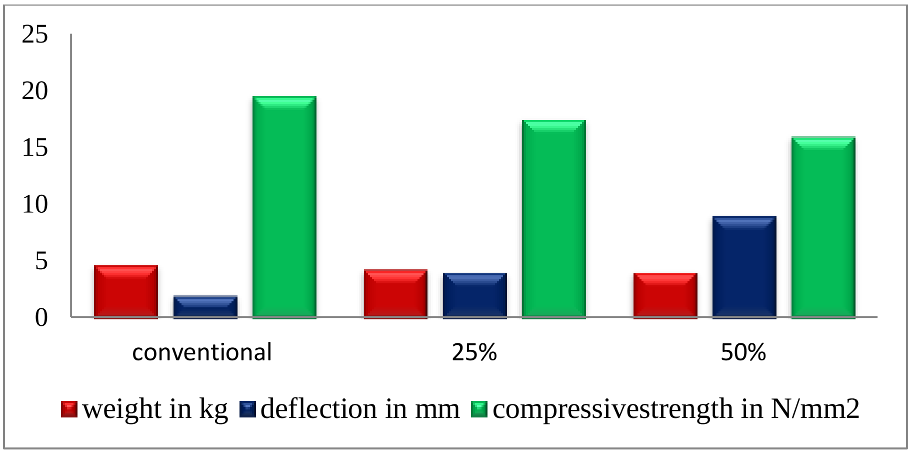

Fig 3. Comparison ofElongationand Strength for Bricks

Table: 8 Deflection of wall involves alternate layer of crumb rubber bricks and normal bricks using steel plate interlocking

Load(KN)	Deflection at side face (mm)	Deflection at front face (mm)	Deflection at centre face (mm)	Regain position(mm)
10	0	0	0	0
20	0	0	0.03	0
30	0	0.02	0.21	0.01
40	0	0.1	0.44	0.03
50	0.04	0.17	0.63	0.04
60	0.08	0.25	0.82	0.06
70	0.11	0.39	1.08	0.07
80	0.18	0.46	1.35	0.08
90	0.23	0.68	1.47	0.08
100	0.33	0.99	1.75	0.1
110	0.49	1.32	1.95	0.22
120	0.78	1.70	2.15	0.55

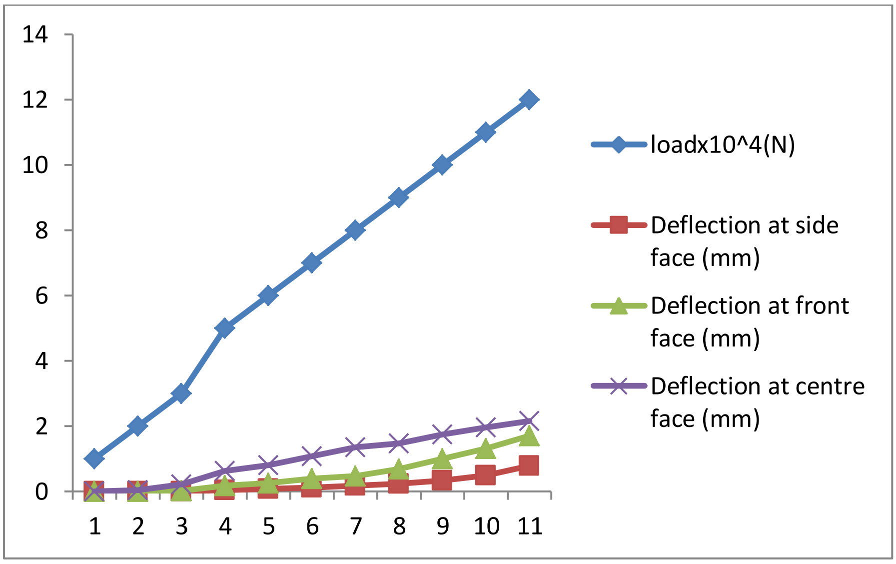

Figure. 4 Deflection of wall involves alternate layer of crumb rubber bricks and normal bricks using steel plate interlocking

Table: 9 Deflection of wall involves crumb rubber bricks using steel plate interlocking

Load(KN)	Deflection at side face (mm)	Deflection at front face (mm)	Deflection at centre face (mm)	Regain position(mm)
10	0	0	0.09	0
20	0.03	0.05	0.5	0.05
30	0.2	0.45	1.26	0.08
40	0.66	0.8	2.3	0.1
50	0.99	1.02	3.56	0.3
60	1.08	2.09	4.0	0.6
70	2.3	3.02	4.8	0.90

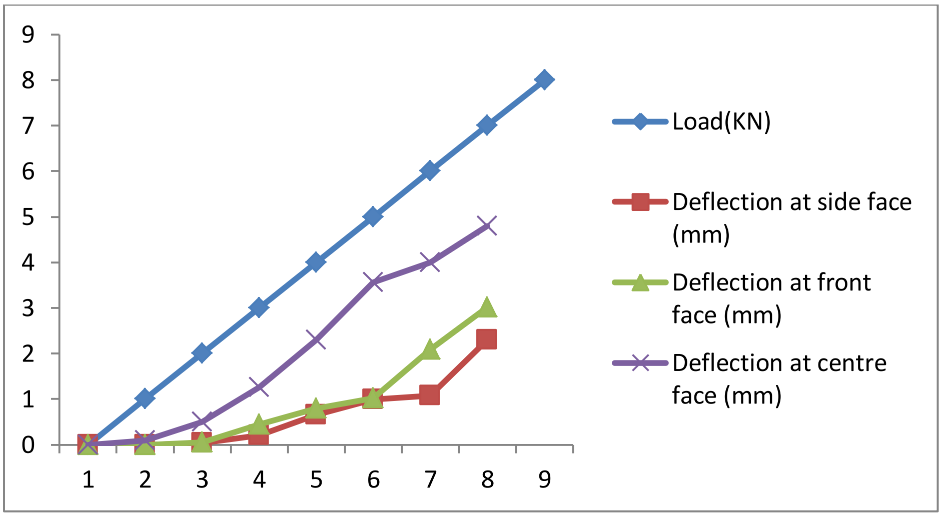

Figure 5. Deflection of wall involves crumb rubber bricks using steel plate interlocking

Table 10 : Deflection of wall involves normal bricks without using steel plate interlocking

Load(KN)	Deflection at side face (mm)	Deflection at front face (mm)	Deflection at centre face (mm)	Regain position(mm)
10	0	0	0	0
20	0	0	0.02	0
30	0	0	0.24	0
40	0	0.06	0.40	0
50	0.09	0.13	0.62	0
60	0.1	0.2	0.86	0
70	0.5	0.78	1.03	0
80	0.9	0.86	1.35	0
90	1.1	1.0	1.41	0

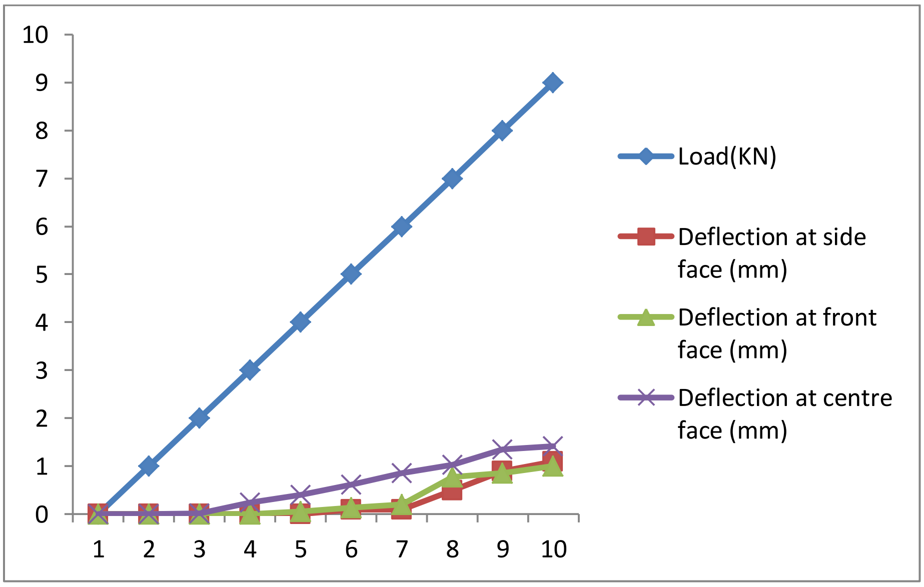

Figure. 6 Deflection of wall involves normal bricks without using steel plate interlocking

Future Works

And further test is to be carried by using nickel titanium in beam and column

VI Conclusion

- Maximum compressive strength and minimum elongation is achieved in conventional brick
- In 25% replacement of fine aggregate by crushed rubber 11.8% is decreased in compressive strength and elongation is twice that of conventional brick
- In 50% replacement of fine aggregate by crushed rubber 22.3% is decreased in compressive strength and elongation is 3.5times that of conventional brick
- Inwall of alternate layer of crumb rubber bricks and normal bricks using steel plate interlocking shows 53% of deflection when compared to conventional brick wall.
- Inwall of crumb rubber bricks using steel plate interlocking shows 70% of deflection when compared to conventional brick wall.
- By comparing both wallof alternate layer of crumb rubber bricks and normal bricks using steel plate interlocking shows 24%of deflection less than the crumb rubber bricks using steel plate interlocking
- In wall of alternate layer of crumb rubber bricks and normal bricks using steel plate interlocking shows 25% of load carrying capacity when compared to conventional brick wall.

- In wall of crumb rubber bricks using steel plate interlocking shows 22.5% of load carrying capacity less than when compared to conventional brick wall.
- By comparing both wall of alternate layer of crumb rubber bricks and normal bricks using steel plate interlocking shows 41.6%%of deflection less than the crumb rubber bricks using steel plate interlocking
- By comparing both wall of alternate layer of crumb rubber bricks and normal bricks using steel plate interlocking shows 39%of regain position greater than the crumb rubber bricks using steel plate interlocking

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