# A Review on the Current Methods of Railway Induced Vibration Attenuations

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**Abstract**: Railway ground borne vibration is a major problem for high-speed and intercity trains. This problem causes many environmental as well as financial problems for railway companies. In the past decades, there have been numerous methods and strategies to avoid the excessive vibration from vehicles. Many of these methods have been tested and used in tracks and surrounding structures while others are still theories. This paper intends to discuss the current practice in railway vibration reduction and the effectiveness of each method for the different track, vehicle and structures. The methods are divided into three groups; in track, in the path and at the destination solutions. For each category, the results from state-of-the-art research and practice have been presented and conclusion on the appropriate methods and strategies for each case has been made.
Track, Vibration, attenuation, dynamics, frequency

**Keywords**: Track, Vibration, attenuation, dynamics, frequency

## 1. INTRODUCTION

Energy dissipation is necessary in almost all structures subjected to dynamic loading including dams and water structures [1], [2], Bridges [3], [4] and tunnels [5], [6]. Since dynamic loading applied on railway track is considerable, a detailed vibration analysis to dissipate energy produced by vehicles should be performed. This problem is especially important in case of high-speed trains.

Since the introduction of high-speed trains in 1964 in Japan, the track-induced vibration has become a major concern in high-speed and urban railways. This is an important environmental and structural issue that is responsible of defects in railway track as well as complains from those who live in track nearby [7].

This issue affects all types of tracks including conventional ballasted track [8],[9], ballastless tracks[10], [11], asphalted track [12] and even more modern rail transportation mode, maglevs [13]. The vibration analysis methods can be divided into three categories: (a) experimental methods; (b) analytical; and (c) numerical methods. There are also hybrid solutions which combine the advantages of each approach to derive better answers.

Analytical solutions have shown a great potential to solve the problem and perform parametric studies to evaluate the impact of many influential parameters on vibration level of vehicle, track and structures. However, application of this approach usually causes the problem to be very complicated which reduces its effectiveness especially in case of three-dimensional modeling and the authors have to oversimplify the model or make it very complicated [14], [15]. It is also shown that simplified linear models that most researchers adapted in their work is not capable of producing accurate solutions[16], [17]. Numerical simulations make the procedures easier but still most numerical models are computationally expensive with many degrees of freedom and huge amount of time is required to solve the equations [18]. Consequently, some authors try to combine different numerical methods [19], [20] or use the experimental and laboratory results [21], [22].

The goal of this paper is to probe into different methods of rail vibrations and compare the results from different methods to give an understanding of merits of each method in different conditions of train operations. It is also the aim of this study to classify the methods based on the location of vibration reduction measures; namely, in track, in the path and at the destination (or structures).

## 2. TRACK BASED SOLUTIONS

The most common way to reduce vibration is to find measures in railroad track or the source of excitations. Since the vibration has not been propagated yet, it can be effectively attenuated by methods that follow.

Rail fastening system has been used to connect rail to sleepers. There are two kind of fastening system: rigid and flexible fasteners. Flexible fastening system provide better vibration attenuation in track [23]. It is also shown that different flexible fastening systems are capable of bearing repetitive loading from vehicles and their fatigue life is satisfactory for different train speed and axle load [24].

Eitzenberger in his literature review on train induced vibrations in tunnels showed that flexible fastening system attenuate vibrations with a frequency between 30 to 50 Hz and maximum vibration reduction of 10dB can be achieved [25].

Figure. *1* shows the vibration reduction due to using flexible fastening systems. As it can be seen in the figure with increasing the frequency, vibration decreases and there is a total difference of 18 dB between flexible and non-flexible fastening systems [26]. Rail pad stiffness also significantly affect the track stiffness and its vibration modes. It is also shown that the condition of rail pads affects the resonance frequency of sleepers which change the track frequencies and reduces the risk of resonance [27].

Other solution to decrease vibration in railway track is elastic layers that are capable of absorbing energy. There are a couple of elastic pads developed for track namely; rail pads, under sleeper pads, and under slab pads.

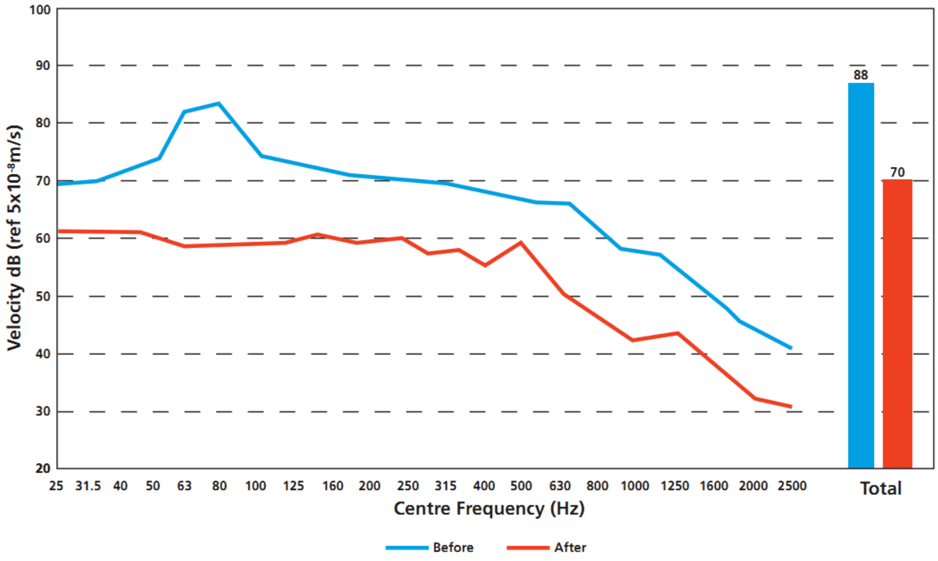


Figure. 1 Vibration velocity level before and after using flexible fasteners [26]

Elastic rail pads are common tools of vibration reduction. Thickness and elasticity of pads can be different for different track conditions. For example, Sol-Sánchez et al [28] considered the use of deconstructed tire rail pads in railroad tracks and concluded that for a high-speed rail track, rail pad thickness should be greater than 7.5 mm, while for conventional tracks, 7.5mm or less pads would be enough to attenuate vibration.

Under sleeper pads is another successful method of vibration reduction in railway track. Johansson et al [29] investigated the effect of pads on dynamic train-track interactions and their results showed that under sleeper pads reduces vibration of rail and sleepers and they are usually effective at frequencies below 250 Hz.

This approach has been extended to slab tracks by using under slab pads and floating slab tracks. There are numerous analyses on the effect of pads on the track vibrations. The idea is to use elastic pads under sleeper and slab to change the vibration characteristics of the whole track. This is usually crucial in case of slab track because slab track has grater stiffness compared to conventional ballasted tracks and they are usually used in urban and high-speed lines. As a result, a thorough vibration analysis is needed for slab tracks.

To investigate the influence of pads with different stiffness and locations in slab track, Hui and Ng [30] conducted an analysis slab track on viaduct. Figure. *2* shows the under sleeper and side pads used in the analysis. The vibration isolation help reduce vibration in case of floating slabs with higher bending resonance frequencies but it is not suitable for high-speed tracks due to excessive deflections. It is reported that 10-45 vibration reduction can be achieved in the frequency range of 25– 250 Hz bands.

Kuo et al [31] conducted a train-track dynamic interaction analysis to investigate a number of track parameters on track vibration including: rail clips, slab bearing and slab mass. Based on the results from the analyses, soft rail clips are very effective in decreasing wheel-rail contact forces and has little effect on track deflection. Slab pads are reported to be different and shows significant deflections so there should be a trade-off between environmental vibrations (propagated to the media) and train vibration (which affects ride comfort).

Increasing mass of slab is another solution to vibration problem. This solution is usually achieved by increasing the slab thickness, consequently, natural frequency of the whole structure reduces. A trade-off between costs of increasing thickness and vibration reduction is needed. The effectiveness of this methods depends totally on the excitation frequency and track type. For example, the findings from analyses indicate that rail vibration for the heavier tracks are slightly higher in case of high-speed tracks. So Arbitrary designs of slab tracks may cause amplification of dynamic responses in rail and slabs for different train speeds.

Since in Ballasted tracks, granular material are used, there are more vibration damping capacities compared to slab tracks. However, vibration propagation from high-speed tracks still exceeds the allowable vibration range introduced by track standards [32]. An elastic layer under ballast material as ballast mat layer is a solution to vibration problem in railway tracks [33].

A numerical finite element analysis performed by Costa et al [34] revealed that depending on the range of excitation frequency, ballast mat can be effective in vibration attenuation. For example, foe frequencies above 40 Hz, up to 20 dB reduction in vibration has been observed. For lower frequency, it has been shown that isolated solution provide better results.

It is concluded that the introduction of mats leads to higher displacements of the rail than the non-isolated methods. It is suggested that to minimize this problem, the mat should be used under subbalast layer.

Subsoil condition proved to be very important factor in vibration reduction or amplification. Fesharaki and Hamedi [35] conducted a finite element analysis to delve into the effect of high-speed rail substructure on ground-borne vibrations. The research examined some parameters including train speed, train axle load and subsoil materials. The results of the study showed that track vibration highly depends on the material properties of track substructure and selecting proper material for track substructure could decrease the vibration by 30%. Other researchers have taken into account the material type [12] and track stiffness [36]. All the study reach to the conclusion that changing the trackbed stiffness and damping has a great impact on track vibration. Some studies show that

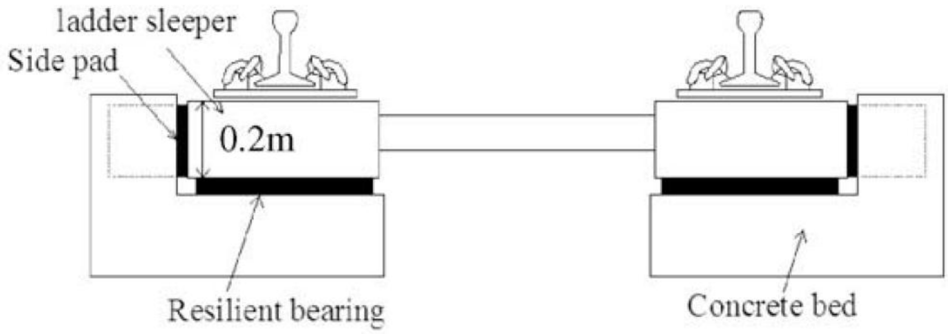


Figure. 2 under sleeper and side pads in slab track [30]

track materials such as embankments can be used to control vibrations. The height and stiffness and embankment is very important to dissipate vibration from high-speed tracks. [37]

A large number of studies have been done on the importance of track quality on track vibration [38], [39]. The finding indicate that track defects can increase vibration level more than 50% so controlling track deficiencies and regular track maintenance are a solution to track vibration.

## 3. VIBRATION SOLUTIONS ON THE PROPAGATION PATH

Another potential solution to railway vibration issue is to attenuate the energy of propagated wave in the surrounding media. In order to do so, the soil characteristics need to be changed. One possible method is open or filled trenches. Solid barriers can be filled by concrete or lime [40]. Figure. 3 shows trenches excavated with width “w” and height “h” in the vibration propagation path to attenuate the energy of waves from railroad track.

Thompson et al [41] conducted a study by coupled finite element/boundary element methods to explore the impact of trench isolation for railway-induced vibration. It is found that the performance of trench in vibration reduction is influenced by the depth and stiffness of the soil layers. The overall vibration reduction achieved in this study is 10 dB which is for a 3m deep trench in a soil with a 3 m deep surface layer.

The influence of trench width and slope was investigated and the results show that increasing the width of the open trench has little influence on vibration attenuation and the performance of trenches with side slopes (45 or 60 degrees) is very similar to that of a vertical trench. The important parameter that shows the performance of the trench is the stiffness per unit area of the barrier material.

Another investigation targeted on both open and in-filled trench with GeoFoam material performed by Alzawi and ElNaggar [42]. The results from the experimental study revealed that the GeoFoam barrier can be considered as an effective alternative for vibration reduction. The barrier can reduce vibrations up to 68%. As part of this study, the depth of barrier explored. It is found that they are more effective for depth greater than 0.6 meters. The findings indicate that an important factor of trench effectiveness on vibration attenuation is the ratio of distance to track to depth of trench. For example, for deeper trench, they should be located at a farther distance from track.

Other researchers have done the same investigation by using numerical methods [43]. Ekanayake et al employed finite element code ABAQUS analyzed a three dimensional model of track and surrounding soil.

The results verifies the conclusion from previous study that width of barrier has little influence of its performance and the depth of barrier has a considerable impact on its vibration reduction ability. The material that might be used as the trench fill also investigated. For instance, comparing the performance of water filled and geofoam filled trenches shows that geofoam barriers outperforms water filled barriers. However, as the distance from the vibration source increases, both types of trenches perform similarly.

As it is mentioned in all vibration study, the frequency of vibration source and vibration characteristics of track and soil is the major item on the efficiency of the methods for vibration reduction. In this case, at lower frequencies, the effectiveness of both water filled and geofoam filled trenches are very close but for higher frequencies of excitation source, geofoam produces better attenuation.

## 4. VIBRATION SOLUTIONS AT THE DESTINATION

Most vibration attenuation methods are implemented at the source or along wave transmission path to the structures. It is believed that these methods are less expensive and more efficient than those performed at the already built structures. But in some cases, it is preferred to conduct vibration reduction measures at destination. For example, in case of a monumental or vibration sensitive building or structures, vibration reduction strategies at the building might be necessary.

Base isolation has been used for many years to reduce vibration in buildings. In 1930s some bearings have been used to reduce the “audible hum” in New York [44].

Evans and Himmel [45] published the results of measurements conducted to determine amplitude of vibration at various locations. The object of the project was to reduce vibration from a turbine and generator rotational frequencies. The analyses show the drilled piers’ partial direct bearing on limestone causes vibration coupling. Reducing the bearing area of pier to limestone does not significantly affects the vibration.

Talbot [46] performed a detailed 3D dynamic model of piled foundation to explore the behavior of foundation vertical, horizontal and rotational directions. A generic model of base-isolation also generated by combining pile and building models. The results indicate that the choice of isolation frequency is very important in its effectiveness and the

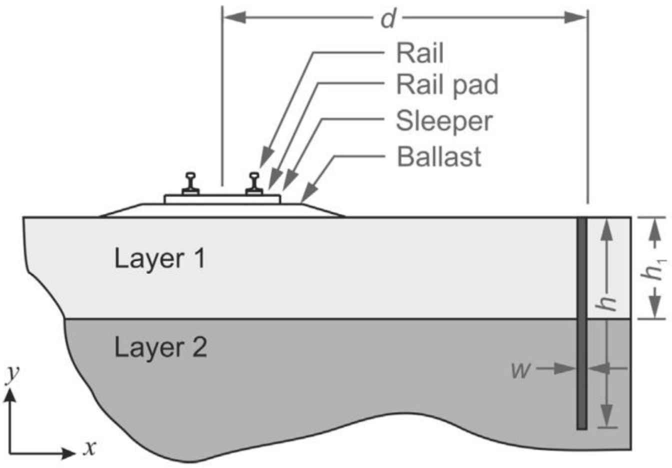


Figure. 3 soil barrier to reduce vibrations[41]

maximum vibration reduction of 15 dB can be achieved. Although effective on local resonance, Damping is found to be insignificant in vibration level.

# 5. CONCLUSION

Vibration of railway track is a very important issue in rail operation and design. With increasing trains' speed and loads the vibration problem has been arisen in many rail lines. Failure to address this issue properly causes great consequences form reducing life cycle of track structure to annoyance to people who live in track neighborhood. To solve this problem, several approaches have been used. From the location of measures points of view, three methods of vibration reduction can be used. Vibration attenuation at the source or railway track is the most popular method and proved to be more efficient compared to other methods. It usually includes using elastic layers under different parts of track including rail, sleeper, ballast and slab (in case of ballast-less track). The effectiveness of these solutions depends on the frequency of excitations and natural frequency of track. Successful methods can change the track frequencies considerably. The second approach is attenuation of vibration along the propagation path by using trenches. Different materials have been used to fill the trenches. The results of analyses for each material are different depending of the track structure, depth of trench and its distance from the vibration source. The third method or vibration reduction in the destination is least popular method and is usually very expensive. It is normally used to reduce vibration of a few monumental or sensitive buildings. As it is explained for other measures, the effectiveness of this method totally depends on the vibration from trains, track structure and natural frequency of the structure. The base isolation should be able to change the frequency of local structure, as a result, the resonance can be avoided. As a general conclusion, it is recommended that a detailed dynamic and vibration analysis should be performed for each case of track and building. So a perfect method of reducing vibration for a case may exacerbate the problem for another track with different natural frequency and track axle load and speed.

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# Speech Forgery Detection Based On Complementary Behavior of Ears

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**Abstract**: The following paper is a implementation of speech forgery detection by our two ear system seen in human species.
**Keywords**: two back propagation neural networks, parallel connection

## 1. INTRODUCTION

The following paper is an implementation of speech forgery detection by our two ear system seen in human species.

## 2. Speech forgery detection from Image forgery detection

Analysis of Image forgery detection mentioned in the reference the algorithm is extended to speech forgery detection.

Image and speech are considered identical with a different base and cardinality of base.

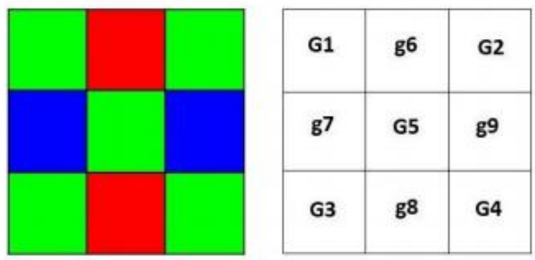
Image is considered to be in two dimensional basis. Analysis of Image forgery detection mentioned in the reference the algorithm is extended to speech forgery detection.

Image and speech are considered identical with a different base and cardinality of base.

Image is considered to be in two dimensional basis. Speech is considered in a different three dimensional base. All functions in the previous work are mapped and approximated into 3 dimensional base.Speech is considered in a different three dimensional base. All functions in the previous work are mapped and approximated into 3 dimensional base.

## 3. Taking the training data

The input data sequence is considered from the speech signal base to image signal base and the input vectors of size 1x5 is taken on this basis. This input is given differentially into two such trained back propagation neural network simulating our ears.




**[G1 G2 G3 G10 G11] given as input where G10 and G11 are from the next matrix.**

## 4. ACKNOWLEDGMENTS

Our thanks to the experts who have contributed towards development of the template.

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# Performance of Composite Beam

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**Abstract:** Composite construction dominates the non-residential multi-storey building sector. This has been the case for over twenty years. Its success is due to the strength and stiffness that can be achieved, with minimum use of materials. The reason why composite construction is often so good can be expressed in one simple way - concrete is good in compression and steel is good in tension. By joining the two materials together structurally these strengths can be exploited to result in a highly efficient and light weight design. In this project, we have determined the flexural strength of composite beams. Various specimens with water cement ratio 0.45 where casted. The specimens were tested for 28 days strength. To evaluate the effectiveness of the composite beams. The results were tabulated and line chats and conclusions were given.

Keywords: Composite beams, Flexural strength, Flexural behavior, Compression, Tension

## 1. INTRODUCTION

A structural member composed of two or more dissimilar materials joined together to act as a unit as known as composite. An example in civil structures is the steel-concrete composite beam in which a steel wide flange shape is attached to a concrete floor slab. The many other kinds of composite beam include steel-wood, wood-concrete and plastic-concrete or advanced composite materials-concrete.

There are two main benefits of composite action in structural members. First, by rigidly joining the two parts together, the resulting system is stronger than the sum of its parts. Second, composite action can be better utilize the properties of each constituent material. In steel-composite beams, for example, the concrete assumed to take most or all of the compression while the takes all the tension.

Steel-concrete composite beams have long been recognized as one the most economical structure systems for both multistory steel buildings and steel bridges. Buildings and bridges require a floor slab to provide surface for occupants and vehicles respectively. Concrete is the material of choice for the slab because its mass and stiffness can be used to reduce deflections and vibrations of the floor system and to provide required fire protection. Since both the steel and concrete are already present in the structures, it is logical to connect them together to better utilize of their strength and stiffness.

Steel concrete composite beams consists of a steel beam over which a reinforced concrete slab is cast with shear connectors. In conventional composite construction, concrete slabs are simply rested over steel beams and supported by them. These two components act independently under the action of loads, because there are no connection between the concrete slabs and steel beam.

The basic concept of composite beam lies in the fact that the concrete is stronger in compression than steel (which is susceptible to buckling under compression) and steel is stronger in tension.

**1.2 Advantages of composite beam:**

- The concrete and concrete is utilized effectively
- More economical steel section is used in composite construction than conventional non-composite construction for the same span and loading
- Depth and weight of steel beam required is reduced.so, the construction depth also reduces increasing the headroom of the building
- Composite beams have higher stiffness, thus it has less deflection that steel beams
- Composite beams can cover for large space without the need of any intermediate columns
- Composite construction is faster because of using rolled steel and pre-fabricated components than cast-in-situ concrete
- Encased steel beam have higher resistance to fire and corrosion

## 2. MATERIALS AND SPECIMENS

### 2.1 MATERIALS

### 2.1.1 CEMENT

Cement is defined as a material with adhesive and cohesive properties which make it capable of binding material fragments into a compact mass. Cement is obtained by burning calcareous and argillaceous materials by partial fusion at about 1450$^{o}$C. Ordinary Portland cement 53 grade was used for casting all the specimens. The ordinary Portland cement is generally classified into three grades, they are 33grade, 43grade, and 53 grade. In this study OPC 53 grade has been used.

Table 2.1.1 physical properties of cement

| S.NO | PROPERTY OF CEMENT | VALUE |
|---|---|---|
| 1 | Grade of cement | 53 grade (OPC) |
| 2 | Specific gravity | 3.13 |
| 3 | Initial setting time | 30mins. |
| 4 | Final setting time | 60mins. |

| | | |
|---|---|---|
| 5 | Normal consistency | 35% |

### 2.1.2 FINE AGGREGATE

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. As with coarse aggregates these can be from primary, secondary, or recycled sources. Aggregates are the major ingredients of concrete, as they constitute 70-74% of the total volume, provide a rigid skeleton structure for concrete, and act as economical space fillers. In India river sand is used as fine aggregate. The sand was washed and screened at site to remove deleterious materials and tested as per the procedure given in the IS 2386-1963.

Table 2.1.2 properties of fine aggregate

| S.NO | PROPERTY OF FINE AGGREGATE | VALUE |
|---|---|---|
| 1 | Specific gravity | 2.65 |
| 2 | Fineness modulus | 2.25 |
| 3 | Water absorption | 1.5% |

### 2.1.3 COARSE AGGREGATE

Coarse aggregate consists of river gravel, crushed stone or manufactured aggregate with particle size equal to or greater than 4.75mm. It shall comply with the requirements of IS383-1970. For the coarse aggregates, the following test has been carried out conforming to IS2386 (part 1). Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste –aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

Table 2.1.3 properties of coarse aggregate

| S.NO | PROPERTY OF COARSE AGGREGATE | VALUES |
|---|---|---|
| 1 | Specific gravity | 2.70 |
| 2 | Size of aggregates | 20mm |
| 3 | Fineness modulus | 5.96 |
| **4** | Water absorption | 2.0% |

### 2.1.4 STEEL TUBE (Hallow Structural Section)

HSS Manufacturing Methods The transformation of steel strip into hollow structural sections (HSS) is the result of a series of operations including forming, welding and sizing. Currently three methods are being used in North America for the manufacture of HSS. Each method meets ASTM A-500 and CSA G-40.21-92 requirements for the manufacture of HSS.

### 2.1.5 POTABLE WATER

Casting and curing of specimens were done with the potable water that is available in the college premises. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Potable water with ph value 7 is used for mixing and curing throughout the experiment.

### 2.2 PREPARATION OF SPECIMENS

### 2.2.1 FLEXURAL SPECIMEN

A steel tube of 1*0.102*0.102m is used as reinforcement for casting beam specimen.

### 2.2.2 CASTING OF SPECIMENS

All the ingredients in the concrete were weighted carefully by the balance. For composite beam specimen -cement, fine aggregate, coarse aggregate were weighted and mixed thoroughly to get a uniform mixture. The mixing is done on a water-tight platform, the required quantity of water was added slowly and wet mixing was done.

The fresh concrete was filled in the moulds layer by layer and each layer was compacted thoroughly by tamping rod. The surface was levelled and finished by using a trowel. The specimen were removed from the mould after 24 hours of casting and kept for curing in the curing tank.

## 3. MIX DESIGN

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible.

### 3.1 OBJECTIVE OF MIX DESIGN

The objective of concrete mix design as follows

- The first objective is to achieve the stipulated minimum strength
- The second objective is to make concrete in the most economical manner. Cost wise all concretes depend primarily on two factors, namely cost of material and cost of labour. Labour cost, by way of formwork, batching, mixing, transporting and curing is namely same for good concrete

### 3.2 MIX PROPORTION

Based on the simplified mix design procedure as per IS 10262:2009, a concrete mix proportions with characteristic compressive strength was designed without the admixtures.

- The grade of concrete $M_{25}$ is used further proportion of 1:1:2 respectively
- Characteristic compressive strength required at the end of 28 days is 25 N/mm$^2$

The mix adopted for the study is tabulated

Table 3.2 mix proportion

| | CEMENT | WATER | FINE AGGREGATE | COARSE AGGREGATE |
|---|---|---|---|---|
| Kg | 4.74 | 2.13 | 4.74 | 9.48 |
| Ratio | 1 | 0.45 | 1 | 2 |

## 4. EXPERIMENTATION

This chapter presents the details of experimental investigations carried out on the test specimens to study the performance evaluation of composite beam. The flexural strength of the composite beam were studied.

### 4.1 EXPERIMENT PROCEDURE

- The concrete typically consists of cement, fine aggregate, coarse aggregate, and potable water
- The mix design for $M_{25}$ grade of concrete and the required mix proportions for the ingredients used are calculated
- Some of preliminary tests are carried out on the materials to be used so that to check their suitability for making concrete
- After casting the specimens they were set free for 24 hours and then the specimens are taken to curing tanks for proper curing
- Then the strength properties such as flexural beam test are conducted for $28^{th}$ day of concrete
- The maximum strength of the casted composite beam is founded.

## 5. TESTING PROCEDURES

### 5.1 PRELIMINARY TESTS ON MATERIAL

Some of the preliminary tests are required to check their suitability of making concrete such as follows

- Specific gravity test
- Setting time test
- Consistency test

#### 5.1.1 SPECIFIC GRAVITY TEST OF CEMENT

Specific gravity of the cement is calculated by using density bottle method. For finding specific gravity of cement kerosene is used

Specific gravity of cement is 3.13

#### 5.1.2 SETTING TIME TEST OF CEMENT

Initial and final setting time on cement is obtained by vicat's apparatus, for the initial setting time of the cement vicat's needle should penetrate to a depth of 33-35mm from the top, for final setting time the vicat's needle should pierce through the paste more than 0.5mm. We need to calculate the initial and final setting time as per IS: 4031(part5)

Initial setting time of cement: 30mins

Final setting time of cement: 60mins

#### 5.1.3 STANDARD CONSISTENCY TEST

The standard consistency test of a cement paste is defined as that consistency which will permit vicat plunger having the 10mm diameter and 50mm length to penetrate a depth of 33-35 from the top of the mould. The basic aim to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (part4)

Standard consistency of cement is 35%

#### 5.1.4 SPECIFIC GRAVITY OF FINE AGGREGATE

Specific gravity of fine aggregate is calculated as 2.65

#### 5.1.5 SPECIFIC GRAVITY OF COURSE AGGREGATE

Specific gravity of coarse aggregate is calculated as 2.70

### 5.2 TESTS ON FRESH CONCRETE

The fresh concrete are tested by following methods

- Slump cone test
- Compaction factor test

#### 5.2.1 SLUMP CONE TEST

Slump cone test is a very common test for determination of workability of concrete. This test was carried out for $M_{25,}$ before casting the specimens

The slump cone value of concrete is 60mm

#### 5.2.2 COMPACTION FACTOR TEST

This test is more accurate than slump cone test and this test is used to determine the workability of low water cement ratio more accurately. The specimen was tested after the surface gets dried the load was applied on the smooth sides without shock and increased continuously till the specimen failed.

The compaction factor value is 0.85

### 5.3 TESTS ON HARDENED CONCRETE

The tests were conducted on the hardened concrete are as follows

- Flexural strength test

#### 5.3.1 FLEXURAL STRENGTH TEST

During the testing, the beam specimens of size 1000mm×102mm×102mm were used. Specimens were dried in open air after 28 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length. Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a materials ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique.

The flexural strength represents the highest stress experienced within the material at its moment of rupture. The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibres are at the largest stress so, if those fibres are free from defects, the flexural strength will be controlled by the strength of those intact 'fibres'. However, if the same material was subjected to only tensile forces then all the fibres in the material are at the same stress and failure will initiate when the weakest fibre reaches its limiting tensile stress.

## 6. FLEXURAL STRENGTH TEST

FIRST CRACK LOAD = 10 kN
ULTIMATE LOAD = 44.6 kN

### 6.1 FLEXURAL STRENGTH TEST

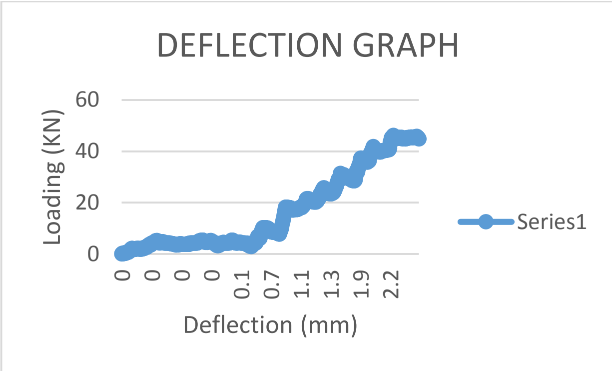


Fig 6.1 Deflection graph

## 7. CONCLUSION

- The test result indicates that split tensile strength increases in M25 grade of concrete
- Flexural strength is maximum at 65 kN where as normal M25 grade can achieve as this much.

### 7.1 SUMMARY

- The use of steel concrete composite beams is much effective than ordinary RCC beam.
- The study concluded that flexural strength of composite beam is achieved as maximum than RCC beam.
- The cost the beam is little higher than the ordinary RCC beam.
- This type of construction is used for high storey building and fire resisting build which is much effective than ordinary RCC construction.

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