Proceedings of

Two days National Conference

On

Sustainable Civil Engineering Materials and Structures (SCMS - 2018)

5 & 6, April 2018

Sponsored by

Indian Space Research Organization, Bangalore

Organized by

Department of Civil Engineering

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Dr. N.G.P. INSTITUTE OF TECHNOLOGY

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Coimbatore-641 048

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National Level Conference

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Organized by

Department of Civil Engineering
Dr. N.G.P Institute of Technology
Kalapatti Road,
Coimbatore - 641 048,
Tamilnadu, India.

Dr. Nalla G. Palaniswami
Chairman
KMCH

Dr. Thavamani D. Palaniswami
Secretary
Dr. N.G.P. Institute of Technology

Dr.O.T.Buvaneswaran
Chief Executive Officer
Dr. N.G.P. Institute of Technology

Dr.K.Porkumaran
Principal
Dr. N.G.P. Institute of Technology.

Dr.P.Muthupriya
Professor & Head
Department of Civil Engineering
Dr. N.G.P. Institute of Technology.

Ms. K.S. Shobana, AP
Ms. V. Priya, AP
Department of Civil Engineering
Dr. N.G.P. Institute of Technology.

Mr.C.Chinnaraj, AP
Department of Civil Engineering
Dr. N.G.P. Institute of Technology.

Objectives

This National Level Conference on Sustainable Civil Engineering Materials and Structures (SCMS – 2018) will be held in Dr. N.G.P. Institute of Technology from April 5th& 6th, 2018. Progress of science and technology in the past decades has made enormous contributions to all walks of life. Research has played an indispensable role in many useful developments. Pursuit of newer and innovative ideas has no limits and therefore activities of research have to continue and grow. The aim of this conference is to discuss topics ranging from technical in Civil Engineering concepts to social and economic issues, and to exchange experience and knowledge between people from industry and academia around the world. The different themes of the conference have been selected accordingly.

Conference Topics

- ♣ Green construction Materials and Technologies
- ♣ Construction Management
- ♣ Construction method and system
- ♣ Optimization and Innovation in Structural Design
- ♣ Environmental impact and green design
- ♣ Local and recycled materials
- ♣ Forensic Engineering & Assessment and retrofitting
- ♣ Structural Health Monitoring System
- ♣ Nano Technology in Civil Engineering
- ♣ Smart materials and Structures
- ♣ Other related areas

Chairman's Message

I am pleased to see that department of Civil Engineering, Dr.N.G.P. Institute of Technology is organizing a conference on Sustainable Civil Engineering Materials and Structures on 5th and 6th April 2018. Civil Engineering is the base for all engineering subjects. From time immortal to new human civilization, its achievements are exhibited only through civil engineering structures. Tamil temple structures, South American and Egyptian pyramids, Babylonian hanging gardens are all examples of civil engineering marvels. Recent dams, roads, bridges and buildings are exhibition of civil engineering.

There are many new types of materials and innovative structures are incorporated in civil works. Prefabricated elements and materials are getting into buildings. Thousands of feet high buildings are manufactured and getting erected in months. Cements, steels, glasses, plastics and sands are manufactured differently and used differently. Strength, longevity and corrosion are tackled differently for different purposes.

Civil engineering is seeing sea of changes in recent years. I believe this conference will enlighten our engineering students with different perspective in civil engineering.

All the best.

With regards,

Dr. Nalla G Palaniswami
Chairman

Secretary's Message

My Hearty Congratulations!

I congratulate the faculty members of the Department of Civil Engineering, Dr.N.G.P. Institute of Technology, Coimbatore for their pioneering effort to conduct a National Conference on Sustainable Civil Engineering Materials and Structures in Civil Engineering during 5 & 6th April, 2018.

I am sure that Participants of the conference will gain deep knowledge from renowned speakers from various places on the theme of the conference. The Civil Engineering field is so dynamic that changes, developments, new practices and innovations are happening at light's pace, and in a whole spectrum of areas.

Such a dynamism can only be captured and sustained by sharing the views, plans, designs and research. National Conferences provide the right climate for such sharing to happen. In that way I have to appreciate and congratulate the Department of Civil engineering for responding with zeal in successfully organizing the National Conference on Sustainable Civil Engineering Materials and Structures (SCMS – 2018).

I Congratulate the Organisers of this event for their hard work and commitment in planning and executing all the tasks for the conference.

I wish that the delegates of this conference would be exposed to the state of the art in materials used and structures designed by Civil Engineers.

With regards,

Dr. Thavamani. D. Palaniswami
Secretary

Chief Executive Officer's Message

I am delighted to know that the Department of Civil Engineering is organizing a National conference on Sustainable Civil Engineering Materials and Structures during 5 & 6th April, 2018.

Indeed, the present scenario of population growth and subsequent demand of construction and infrastructure development needs, gives challenges to the Civil engineers to provide a sustainable built environment for the present and future generations. I am sure the conference will bring new ideas on Sustainable Civil Engineering Materials and Structures through which the students, researchers, engineers and scientists will highly be benefited.

I express my heartfelt appreciation to the organizers and I wish the conference a great success.

My best wishes for the Conference.

With regards,

Dr.O.T.Buvaneshwaran
Chief Executive Officer

Principal's Message

Warm and Happy greetings to all. I am immensely happy that, department of Civil Engineering of Dr.N.G.P. Institute of Technology is organizing ISRO Sponsored National Conference on Sustainable Civil Engineering Materials and Structures (SCMS 2018) on 5th & 6th April 2018 and is going present a collection of various technical papers in the proceedings.

I understand that very eminent keynote speakers from various industries and institutions are going to deliver valuable topics of current research interest in sustainability concept implemented in design, construction and maintenance in civil engineering structure. I am convinced that the discussions of this conference will contribute to the latest scientific findings and achievements among civil engineers across the globe.

Under the able guidance of our Chairman and the Secretary Madam continues to march on the way of success with confidence. The sharp, clear sighted vision and precise decision making powers of our management has benefited our college to say competitive.

I have great pleasure in congratulating the organizers of the conference who have endeavored with enthusiasm in organizing this mega event in our College.

I would like to congratulate the Convener Dr.P.Muthupriya, Professor and Head, Department of Civil Engineering, Organizing Secretaries Mr.C.Chinnaraj, Assistant Professor, Department of Civil Engineering, Ms.K.S.Shobana, Assistant Professor, Department of Civil Engineering and Ms.V.Priya, Assistant Professor, Department of Civil Engineering, staff members, participants from our College and other institutions in India and abroad for their efforts in organizing and participating in this conference and wish the conference all the success.

With regards,

Dr.K.Porkumaran
Principal

Organizing Committee

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Dr. Nalla G. Palaniswami
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Dr. N.G.P. Institute of Technology.
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Treasurer

Mr.C.Chinnaraj, AP
Department of Civil Engineering
Dr. N.G.P. Institute of Technology.

KEY NOTE SPEAKERS

Keynote Speaker	Name &Designation	Topic
	**Dr.Manu Santhanam** Professor Civil Engineering Indian Institute of Technology Madras	Effect of Hydraulic Retention Time on the Filtration Performance of Porous Concrete
	**Dr.R.Senthil** Professor Civil Engineering Anna University Chennai	Behaviour of Composite Space Truss
	**Prof D.Venkat Reddy** (Rtd -HoD of Civil Engg-NITK)-Editor in Chief International Journal of Earth Sciences and Engineering & Consulting Faculty Larsen &Toubro-Ltd-Heavy Civil Infrastructure IC HQ-Chennai	Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings
	**Dr.R.N.Uma** Professor & Head Civil Engineering Sri Ramakrishna Institute of Technology Coimbatore	Applications of Nano-Technology in Environmental Engineering
	**Dr. J. Karthikeyan** Associate Professor Civil Engineering National Institute of Technology Tiruchirappalli	Semi-Light weight Wood Ash aggregate concrete
	**Dr.S.P.Jeyapriya** Assistant Professor Civil Engineering Government College of Technology Coimbatore	Improvement methods of Weak soils
	**Mr.S.Jagadeesh Kannan** Managing Director & Structural Consultant Archetype Design Services Pvt Ltd. Coimbatore	SustainableDevelopment in Structural Engineering - Pre Engineered Steel Buildings

KEY NOTE PAPERS

CONTENTS

EFFECT OF HYDRAULIC RETENTION TIME ON THE FILTRATION PERFORMANCE OF POROUS CONCRETE

Murugan Muthu[(1)], Manu Santhanam[(1)] and Mathava Kumar[(2)]

(1) Building Technology and Construction Management Division, Department of Civil Engineering, Indian Institute of Technology Madras, Chennai 600 036, Tamil Nadu, India

(2) Environmental and Water Resources Engineering Division, Department of Civil Engineering, Indian Institute of Technology Madras, Chennai 600 036, Tamil Nadu, India

Abstract

This study investigates the effect of hydraulic retention time on the filtration performance of porous concrete for removal of lead. Porous concrete, which is made of cement, gap-graded coarse aggregates and water, can present a way forward for slow filtration, as it allows the water to percolate through its interconnected voids. Cylindrical porous concrete specimens of size 100 × 150 mm (ø × H) having flow rate of 626 ± 301 mL/min were prepared and then cured in tap water for a period of 7 days. Up to 86% and 98% of Pb were chemically trapped in the porous concrete specimens after passage of dilute solution containing 8 mg/L Pb through such specimens maintained with 30 cm constant head and trickling head respectively. This suggests that the increase in residence time increased the filtration of heavy metal by the porous concrete.

1. INTRODUCTION

Porous concrete is a special type of concrete composed of cement, water, gap graded or blended coarse aggregates, and additives with little or no fine aggregates [1-3]. Porous concrete pavement system helps in groundwater recharge by providing channels for infiltration of storm water through the inter-linked voids that prevail over the entire depth [4-6]. Porous concrete is used for various functions in the form of pavements, walls, and tile drains for the purpose of water infiltration, thermal insulation, and noise control activities [1, 7-9].

The general applications of porous concrete are in parking lots, green house floors, tennis courts, zoo areas, low volume roads, patios, shoulders, noise barriers, slope stabilization, drains, swimming pool decks and friction course for pavements [9]. Porous concrete pavements are eco-friendly in terms of groundwater recharge by allowing the storm water to runoff through the coarse pore structure [10, 11]. Furthermore, the acoustic properties of porous concrete help to reduce the noise generated by vehicles on the road pavements [9]. However, only a few studies have reported the characteristics of stormwater percolated through the porous concrete, which is generally a composite of rich cementitious matrix interlaced with coarse aggregates.

Groundwater contamination is reduced when the dissolved heavy metals present in storm water are adsorbed on the inner pore walls of porous concrete pavements [12-14]. Fresh and clean water is essential for the survival of living beings. Ground and surface water reserves are heavily contaminated by biological, organic, inorganic and toxic pollutants. These render the water unsafe for human consumption, irrigation and industrial needs [15]. In the future,

people belonging to economically weaker sections and rural communities will find it difficult to afford clean water [16]. This problem can be overcome by developing economically affordable solutions to filter the polluted water [17]. Haselbach et al. [12] have reported that porous concrete maintained with a trickling head was able to chemically trap 90 % Cu and 87 % Zn from the dilute solutions containing 0.02 mg/L Cu and 0.10 mg/L Zn after passage.

This paper attempts to develop a concrete-based water filtration system to address the problem of removing the toxic heavy metals, especially Pb from industrial effluents. This system is based on porous concrete. Although the characteristics of water percolated through the flow channels of porous concrete have been studied, the use of such concrete for water filtration is still a challenge due to various factors like control over pore size distribution, filtrate characteristics, lime leaching and sediment blockage [12, 18-22]. The hydraulic conductivity of porous concrete is found to influence the characteristics of water after passage. In this paper, the effect of hydraulic retention time on the filtration performance of porous concrete was studied. Lead containing solution having concentrations of 8 mg/L was passed through the cylindrical porous concrete specimens mounted on the permeability set up maintained with 30 cm constant head and trickling head respectively. The experimental findings are discussed in this paper.

2. MATERIALS AND METHODS

53 Grade ordinary Portland cement (OPC) and crushed granite coarse aggregates conforming to IS 12269 and IS 383, respectively, and 0.5 wt% polycarboxylic ether (PCE)-based superplasticizer were used in the preparation of porous concrete mixture. This mixture was designed to have an aggregate to cement ratio (a/c) and water to cement ratio (w/c) of 4 and 0.32. Table 1 lists the gradation of aggregates that were used in this study.

Table 1: Gradation of aggregates that were used in this study

Aggregate size fraction	6.3 to 4.75 mm	4.75 to 2.36 mm	2.36 to 1.18 mm	1.18 mm to 300 µm	≤ 300 µm
% by weight	45	25	20	5	5

Cylindrical porous concrete specimens of size 100 × 200 mm (ø × H) were prepared using iron moulds. A Marshall hammer having a foot diameter of 98.4 mm was the tool used to have uniform compaction. The compaction was performed by dividing the concrete into three layers. The fresh concrete required for each equal layer was weighed, poured into the mould, and compacted with 26 blows; after the top layer was compacted, the top surface of fresh concrete was finished using a trowel. The cylindrical specimens were demolded after 24 hours and then cured in tap water for a period of 7 days. At the time of finishing the concrete surfaces using trowel, the bleed water containing cement slurry was noticed to occupy the coarser voids at the top of the specimen. Furthermore, some cement slurry had also settled on the bottom part of the cylinder. To obtain a uniform sample of the porous concrete, slices from the top and bottom of the cured specimens of about 25 mm thickness were removed using a diamond-tipped saw. The sliced specimens were used to analyse the filtration characteristics.

Dilute solution containing 8 mg/L Pb was prepared using lead (II) nitrate salts and then stored in a reservoir having flow control arrangement. This solution was passed under gravity through the concrete specimens mounted in the permeability set up for a period of 60 minutes. A head of 30 cm or a trickling head was maintained constantly over the concrete specimen for the whole testing period by precisely regulating the flow control valve of the solution reservoir, as schematically illustrated in Figure 1.

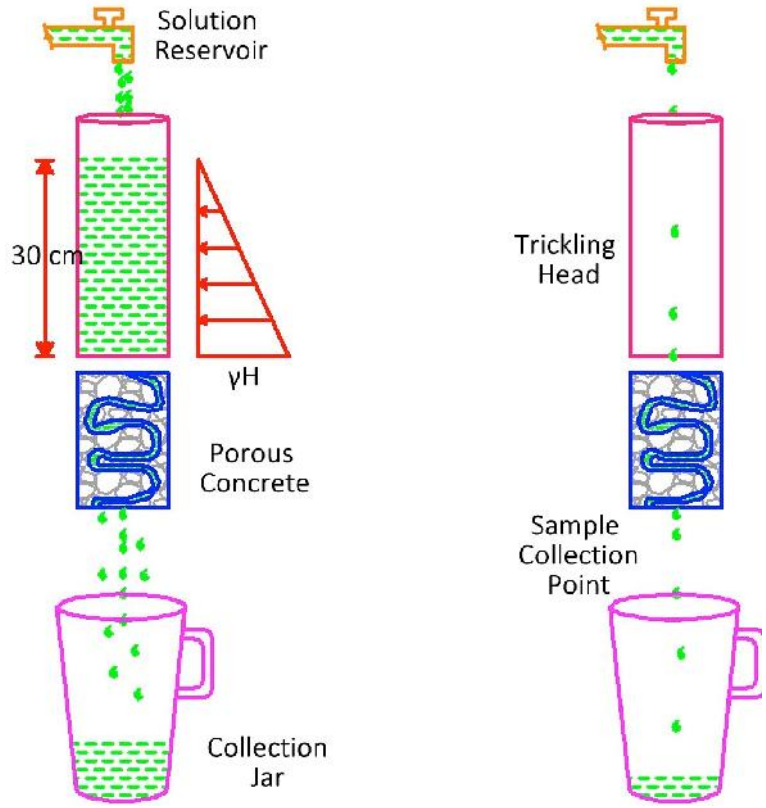

Figure 1: Permeability testing of porous concrete maintained with a 30 cm constant head and a trickling head

A small amount of filtrate, approximately 15 mL, was collected at every 15 minutes and the remaining was collected in the plastic jar that was kept below the concrete specimen. The amount of Pb remaining in the collected filtrate was analysed using inductively coupled plasma mass spectrometry (ICP-MS).

In this study, the void structure inside the porous concrete was imaged using 3-dimensional X-ray tomography. Concrete specimens of size 40 × 100 mm (ø × H) were cored and sliced from the 100 × 200 mm concrete specimens using core cutting machine and Diamond-tipped saw respectively. These specimens (in dried condition) were then scanned using X-rays generated at a voltage and current of 120 kV and 70 µA respectively. The scanning rate was maintained around 4 milliseconds per image. The GE phoenix v|tome|x s 3-D X-ray Computed Tomography (CT) machine, used for this study, was fitted with a Caesium Iodide flat panel based detector. The resultant 2-dimensional radiographs were extracted from the

acquisition software named Phoenix datos|x CT. Next, their 3-dimensional reconstruction was performed using the software VGStudio MAX version 2.2.

3. RESULTS AND DISCUSSION

3.1 X-ray tomography images

Figure 2 illustrate the 3-dimensional tomography images of porous concrete that was used in this study.

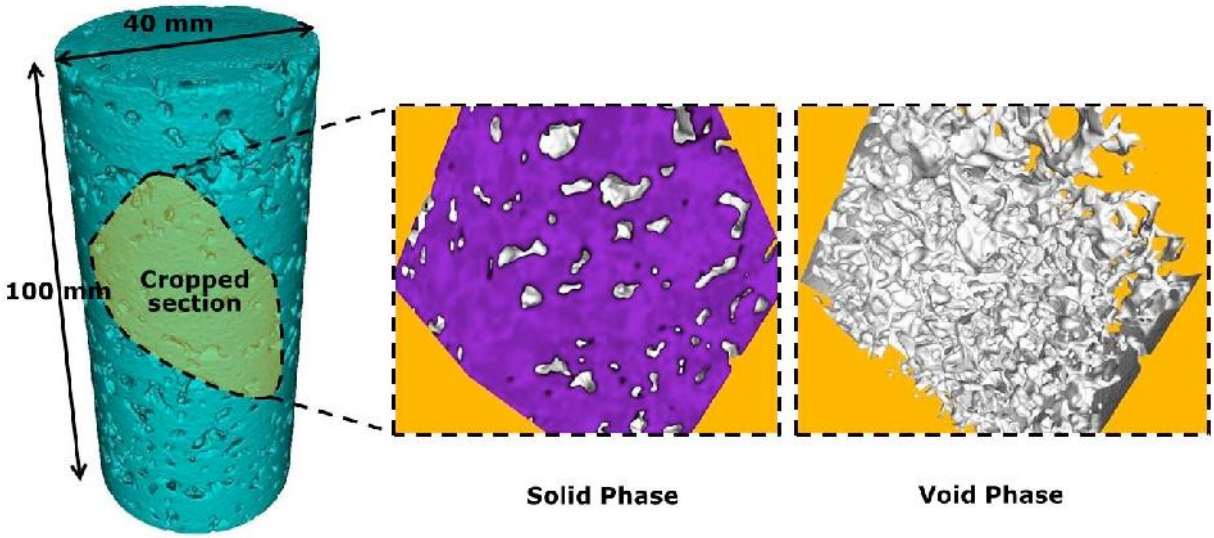

Figure 2: 3D X-ray CT image illustrating the presence of void structure inside the porous concrete specimen that was used in this study

Firstly, the 3D CT image of porous concrete specimen was sectioned into multiple shapes to clearly visualise the interconnected voids inside the material. This was also done to remove the noise created by the exterior surface of the CT image which was in direct contact with the low dense material (air).

The connected voids were noticed to be irregular and highly tortuous, which suggests that the porous system could be highly prone to sediment blockage. The reconstructed software named VGStudio Max 2.2 has in-built algorithms and modes which can locate the pores or voids with high contrast inside the material. These algorithms control the grey scale histogram of the CT image.

3.2 Constant head permeability test results

Permeability set up, as suggested by Sonebi and Bassuoni [23] was fabricated for this study and thereby the flow rate of porous concrete was determined as 626 ± 301 mL/min. This flow rate was found to be similar to the sand filters that are used in water treatment plants. Figure 3 illustrate the lead ions remaining in the filtrate after passage of dilute solution containing 8 mg/L Pb through the porous concrete specimens maintained with 30 cm constant head and trickling head.

It may be noticed from the results that the porous concrete was able to trap Pb significantly from aqueous solutions. Up to 86% and 98% of Pb were chemically trapped in the porous concrete specimens after passage of dilute solution containing 8 mg/L Pb through such specimens mounted on the permeability set up maintained with 30 cm constant head and trickling head respectively.

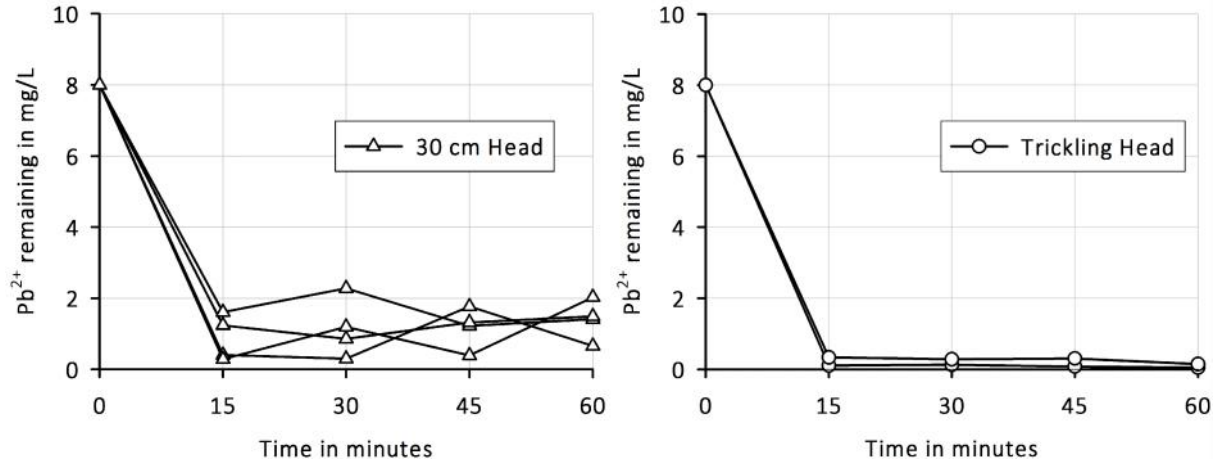

Figure 3: Lead ions remaining in the filtrate after passage of Pb containing solution (8 mg/L) through the porous concrete maintained with 30 cm constant head (left) and trickling head (right)

The presence of hydroxyl and carbonate ions in the flow channel of porous concrete had interacted with the Pb ions and thereby got precipitated as lead hydroxide and lead carbonates. This effect suggests that the heavy metal was removed because of co-precipitation. Apart from this, the decrease in flow rate had increased the residence time and thereby the filtration performance of porous concrete was enhanced.

4. CONCLUSIONS

The key findings from this study are listed as below:

- The interconnected voids inside this system were visualised using 3-D X-ray CT images, which suggested that the porous matrix was highly tortuous.
- Porous concretes maintained with 30 cm constant head and trickling head had trapped the Pb ions up to 86% and 98%, which suggests that the hydraulic retention time influences the concentration of heavy metals that are required to be filtered using porous concrete.

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Behaviour of Composite Space Truss

Senthil R

Professor and Head ,Division of Structural Engineering Dept. of Civil Engineering, Anna University Chennai,

1.Introduction

Now a days space trusses have been widely used for long span and column free structures. It have been used in places like exhibtion hall, airports hangers and gymnasiums.From the previous studies it has been found that failure of the space truss is due to the sucessive buckling of compression – chord members. Mezzina et al. (1975) and Schmidt et al. (1980, 1982) , have indicated that space trusses may fail in a brittle and unstable manner. The buckling of one member due to overloading can trigger a progressive collapse of the whole structure, in which successive members fail in a rapid sequence. El-Sheikh and Mc Connel (1993) studied the behaviour of space truss with overstrengthened top chord members and concrete slab over the top chord members. The study revealed that the composite concrete top chord is more effective in reducing the buckling problem by increasing the stiffness of the structure. El-sheikh (1996) studied the effect of supports settlement on the strength of space trusses. The aspect ratios and supported conditions were varied in the study. It was identified that the corner supported space truss showed low sensitivity due to their lower torsional stiffness. The edge-supported trusses showed high sensitivity for settlement of supports at mid-edge points and low sensitivity to settlement of corner supports. Shaaban (1997) studied the shear interaction and the behaviour of composite space truss with timber board and compared with the non-composite space truss. The results reported that the load carrying capacity and the ductility are improved due to the composite action between the steel truss and timber board. El-sheikh (1998) fitted the force limiting devices in the critical compression member and observed that ductility and load carrying capacity were improved. It is limited to use force limiting devices in the one or few members of the space structures due to economical point of view. Sebastian and McConnel (2000) have tested the composite truss consisting of RC slab on profile steel sheeting for the highway loading which was proposed for the fast erecting schemes of bridges. Fulop et al. (2004) conducted experiments on space truss with concentric and eccentric loads. The collapse of truss was due to the local buckling of two opposite diagonals at the top centre joint. Kim et.al (2006) have studied the ultimate load testing of the hypar space truss with post tensioned member and shown that the hypar space truss has significant structural strength. Lakshmikandhan et.al (2010) have carried out the parametric study on the behaviour of steel and composite space structures using ANSYS and concluded that top concrete slab enhances not only the strength of the top chord members but also increase the strength and stiffness of the system. As observed from literature, the composites perform better than non-composite truss for normal and abnormal loading conditions. The composite space truss is recommended as the best suitable for the implementation, in which the tension carried by the steel and the compression carried by concrete. In this paper the ultimate load carrying capacity of composite space truss was carried by introducing steel plates and bolts to transfer shear from concrete to space truss. The influence of two points loading on to the composite action in terms of strength, stiffness, slip and energy absorption have been studied and compared with the analytical results.

2. Details of Specimen

The double layer grid of size 3m x 2m x 0.71m was assembed using tubular members , mero connector , bolt, sleeve and dowel pin. The detail of the specimen is given in Table 1. The tubular

members have tapered cone sections welded to each end . Integral with each cone there is a connection bolt , sleeve with slotted hole and pin to allow the bolt to be rotated and tightened. The mero connector of diameter 92mm with the 18 threaded holes of diameter 16mm were used . Figure 1 and 2 show the mero connector and space truss with shear connectors .The stud type shear connectors were screwed into the top mero node connectors along with the flat mild steel plate . Theses steel plates runs over the top chord members in order to achieve the composite action.The concrete slab of thickness 50mm was cast with M25 grade concrete over the space truss of size 3 x 2m.

Table 1. Details of Specimen

Details	Specifications		Nos
Node Connector	Diameter	-92mm	18
	Hole Dia	-16mm	
	No of Holes	-18	
Tubular member	Diameter	-72.4mm	48
	Thickness	-2.6mm	
	Length	-1000mm	
	Top Chord	-17	
	Bottom Chord	-07	
	Diagonal	-24	

Fig.1. Mero node Connector

3. Experimental Set up

The composite space trusses were fabricted to test under two point loading condition. The schematic view of the experimental setup and the photographs of the specimen with loading condition are shown in Fig. 3 and 4.

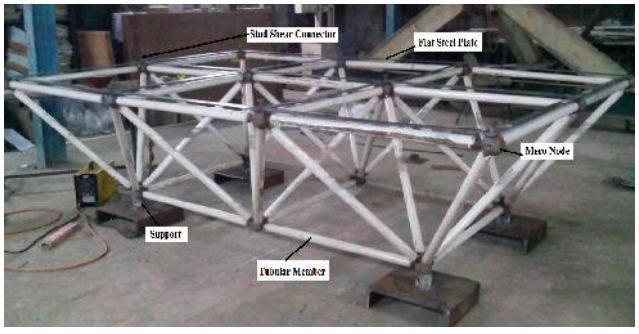


Fig. 2. Space truss with shear connectors

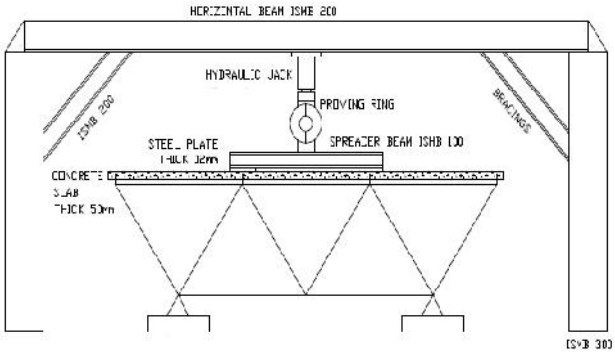
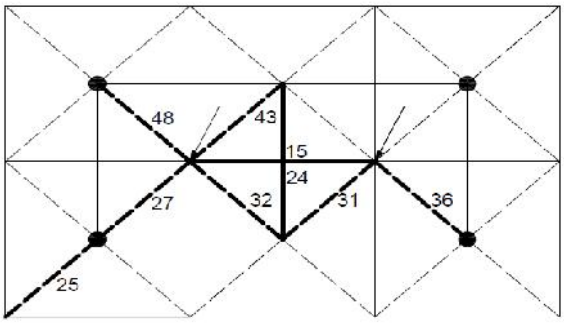


Fig. 3. Typical view of the loading frame and specmen(Not to scale)

Fig. 4. Test in Progress

The mild square steel plate of size 150 mm having a 16mm c-groove are placed at a distance of L/4 from the supports. The standard I section ISMB 200 with 32mm diameter rods welded at the bottom flange, at a distance of 1m apart is placed on the groove over the plate. A 50 ton hydraulic jack is fixed with the loading frame for applying load.The load is measured with a proving ring which is kept between the jack and the I section. The experimental setup employed fifteen strain gauges and ten dial gauges. These are fixed in position for measuring strain, mid span deflection and end slip. The Fig. 5. provides position of the strain gauges and dial gauges.



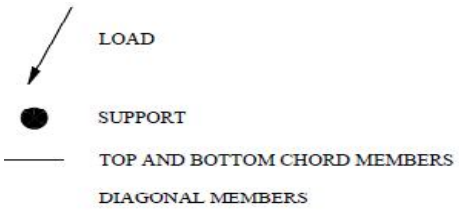


Fig.5. Layout of strain gauge positions in the members

In the layout the numbers represents the places were the strain gauges fixed. The strains were recorded using strain indicator. The ultimate load carrying capacity of composite space truss with shear connector increased without causing any failure of top chord space truss members. From the experimental investigations, the composite space truss with the shear connectors performed well. Moreover no any slip or uplifting between concrete and space truss was observed. The composite space truss with shear connectors exhibited full shear interaction with remarakable increase in the load carrying capacity.

4. Analytical Study

The finite element program ANSYS version 12.0 was used in the present study to investigate the ultimate behaviour of composite space truss subjected to two points loading. The three- dimensional finite element model has been developed to study the nonlinear behaviour of composite space truss. The element type SOLID65 was used for the three-dimensional modeling of concrete slab and space truss members were modeled using BEAM 4 which is three dimensional elastic elements. The nodal solution of the composite space truss is shown in Fig. 6.

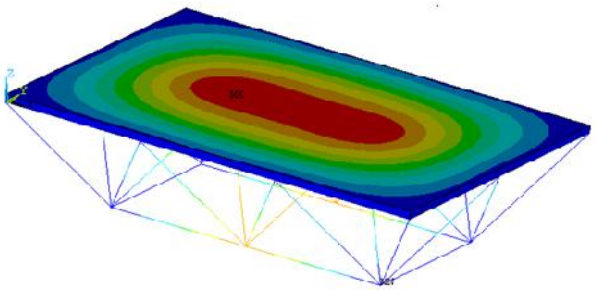


Fig. 6. Finite Element Nodal Solution for the composite space truss

5. Results and Discussion

The composite space truss of size 3 x 2m with the concrete slab thickness of 50mm without profile decking sheet was tested under the two-point loads. The load was increased in steps, and the corresponding deflection at centre of the slab, centre of the top and bottom chord tubular member and lateral deflection in node and slab were measured up to the maximum load. The experimental and analytical behaviour of composite space truss are shown in Fig. 7.The analytical results corroborate the experimental results which in turns validate the experimental study. The ratio of the ultimate load and deflection between the experimental and analytical model are given in Table 2.

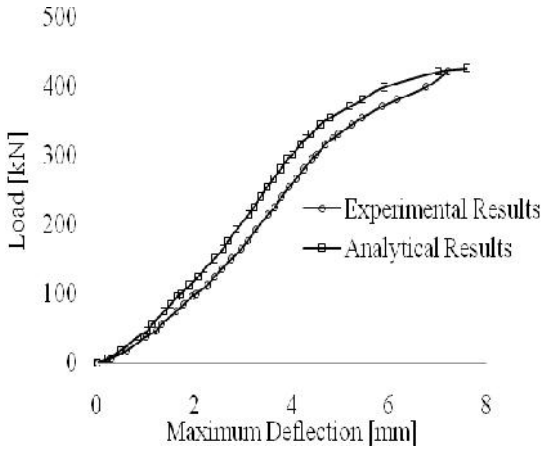


Fig. 7. Experimental and Analytical behaviour of the Composite Space Truss

Table 2. Comparison between Experimental and Analytical Results

Details	Results		ANSYS / EXPT
Ultimate Load P_u(kN)	P_u(ANSYS)	425	1.01
	P_u(EXPT)	420	
Maximum Deflection Δ_c(mm)	Δ_c (ANSYS)	7.6	1.05
	Δ_c (EXPT)	7.2	

In general, the stiffness is defined as the ability to resist lateral deformation. In the present study stiffness values are calculated as the ratio of the load increment to the corresponding increase in measured displacement. The variation in the stiffness between experimental and analytical model of the composite space truss are shown in Fig.8. It was observed that the stiffness decreases with an increase in load. Also, it showed that the analytical model is stiffer than the experimental model.

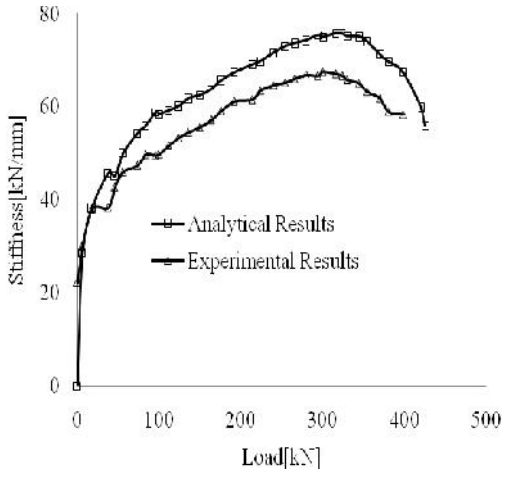


Fig. 8. Load-Stiffness behaviour of the Composite Space Truss

The maximum deflection was reached in the composite space truss with a small slip of about 0.82mm.The slip in between node connector and concrete slabs were measured and plotted in Fig9. The study revealed that the composite action was ensured between the node connector and concrete slab of the space truss without decking sheet.

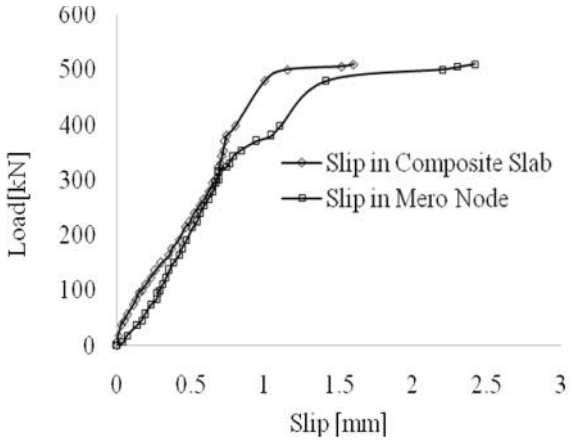


Fig. 9. Load – Slip Curve of the Composite Space Truss

The concrete slab over the steel space truss improved the behaviour of the truss by the means of composite action. A ductile behaviour of the composite space truss was achieved because the top chord member is not been subjected to more compressive load. A sudden brittle or bucking failure of the top chord members was not experienced in the experimental test. The Load – strain behaviour of top, bottom and diagonal members are shown in Fig. 10. It was observed from the curve, the strain recorded in top chord member was less when compared to the bottom and diagonal members.

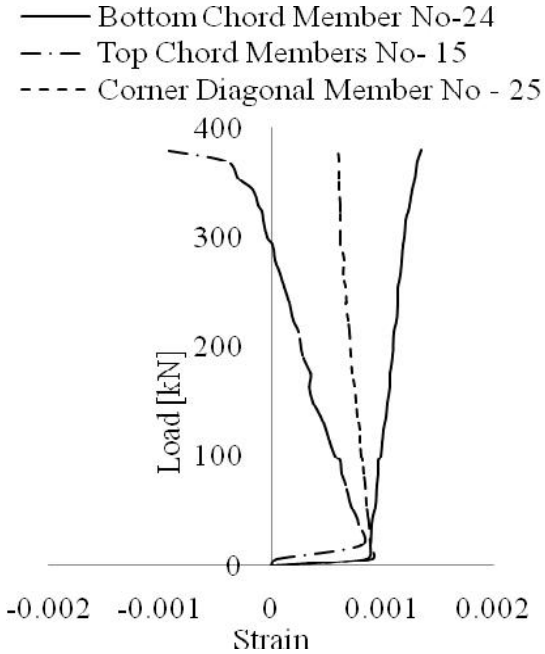


Fig. 10. Load – Strain behaviour of the Space truss members

As illustrated in Fig. 5.the members 27, 32, 43 and 48 are the diagonal members under the point load .The strain from those members were recorded using stain indicators. The variations of the strain in diagonal members are plotted in Fig.11. The members 27 and 32 behaved symmetrically. It was observed that the variation of strain is almost uniform irrespective of the members 27 or 32. A similar failure behaviour was observed in the diagonal members 43 and 48 .It was noted that the members 43 and 48 showed the compressive strain until it reached the load of 350kN and beyond that buckling of the members takes place up to the ultimate load. Beyond 350kN, the recorded strain was tensile. The strain in the concrete slab was measured using strain gauges fixed top and bottom of the slab at the center (along X and Y directions). The load versus strain characteristics of the concrete slab over the space truss are shown in Fig.12. It was recorded that the maximum strain in the composite slab is 0.0001.Moreover it was observed that the top and bottom surface of the slab were subjected to tensile and compressive stresses respectively.

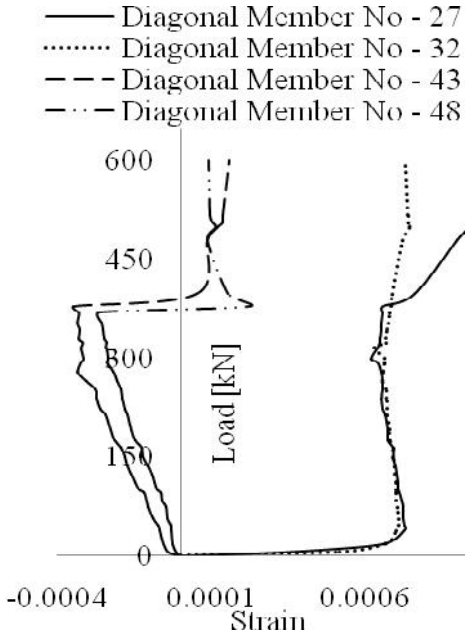


Fig. 11. Load – Strain behaviour of the diagonal members

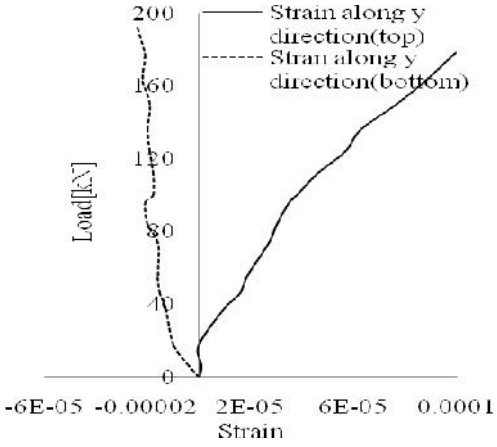


Fig. 12. Load-Strain behaviour of the composite slab

The energy absorption of composite space truss was derived from the load deflection plots. It was calculated up to the ultimate load by calculating the area under the load deflection curve. The energy absorption from the experimental study of composite space truss is about 2016 Nm and from

the analytical study is about 2153 Nm. The maximum central deflections of the composite space truss were compared with theoretical values. Either the experimental Δc(EXPT) or the analytical Δc(ANSYS) deflection 7.6mm and 7.2mm respectively was lesser than the maximum allowable deflection Δ_{all}(L/360) of 8.33mm.

6. Conclusions

The behaviour of composites space truss of size 3m x 2m x 0.7m with a top concrete slab having thickness of 50mm was studied experimentally under two point loading. This study was carried out on the composite space truss without metal decking sheet. The same model was also analysed using ANSYS. The study elaborate that the composite space truss increases strength, stiffness and energy absorption capacity. From the experimental and analytical study, the following conclusions were drawn.

1. The ultimate load carrying capacity of the composite space truss increased with a minimum slip of 0.82mm. Thereby composite action between the steel truss and concrete slab ensured by using Stud and flat steel plate as shear connector without metal decking sheets.
2. In the experimental study, the failure pattern of the composite space truss showed the overall deflection and clear yield line patterns.
3. The experimental and analytical stiffness and deflection of the composite space truss were compared and the percentage difference between them is within 12%.
4. The energy absorption capacity of the experimental and analytical model is 2016Nm and 2153Nm respectively.
5. The ductile behaviour of the composite space truss was achieved without causing sudden brittle failure of top chord members.

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Semi-Light weight Wood Ash aggregate concrete

Dr.J.Karthikeyan, Associate Professor, Department of Civil Engineering, National Institute of Tecnology –Tiruchirappalli 620015

BACKGROUND AND BRIEF HISTORY

During the Indus Valley civilization as early as 3000 BC, the towns of Harappa and Mohenjo-Daro were built using lightweight aggregate concrete(LWAC). In Europe, two thousand years ago, the Romans were built the Pantheon (shown in figure 1), the aqueducts, and the Colosseum uses LWAC (Source: From the book of Satish Chandra and Leif Berntsson, Sweden). Light weight concrete was first patented in 1923 mainly for use as an insulating concrete. With increasing demand, the non-availability of natural lightweight aggregates, factories and industries have been seriously involved in the production of artificial lightweight aggregates.

Fig 1.The roman temple, Pantheon, built in A.D.118 (Source: web)

The rapid depletion of natural resources from the environment leads to the demand for the use of renewable resources. Utilization of wastes emitted from the various factories and industries was increasing day by day. Biomass such as wood barks, wood chips, and saw dust is a good source of renewable energy producers. Those wastes are commonly used as a fuel to generate heat energy. However, the combustion of these wood wastes produces enormous amount of ash. Wood ash is a tamarind bark combustion product composed of (shown in figure 2) which creates the adverse problems because it can easily spread in the air due to its fineness causing health issues for living beings and it need separate land space to dump it and also it contaminates the ground water by leaching toxic elements.

Fig 2. Disposal of Wood ash(barks of tamarind tree) in open environment

Limestone plays a significant role in the production of cement. This sedimentary rock is composed mainly of skeletal fragments of marine organisms such as coral, forams, and molluscs. Its major materials are the minerals calcite and aragonite, which are different crystal forms of calcium carbonate ($CaCo_3$). Wood ash (especially, by tamarind bark combustion) contains high CaCO3 content. Hence, an attempt has been made to utilise this treasure in concrete production. The applications of wood ash in concrete include cement replacement, filler.

Then, from a novel perspective, we thought, why can't we use it in the form of aggregate? After a lot of trials and experimentation, we finally made coarse aggregate by using wood ash as a main ingredient using pelletization techniques.

SUPPORTING MATERIALS AND MANUFACTURING PROCESS

The wood ash (shown in figure 2) were collected and further processed in two stages (i.e.) (i) Sieving (ii) ball milling. At first stage, the wood ash material was sieved in 2.36 mm sieve to eliminate unburned coal pieces and unwanted wastes present in it then the passing material was crushed in the ball mill for period of 20 minutes at second stage. The fine wood ash powder is shown in figure 3. Basically wood ash is an organic material used as a fertilizer by the presence of potash and calcium. In present research, semi light weight concrete is prepared by using light weight wood ash pellets (WAP) (shown in figure 4) as a coarse aggregate which has bulk density in the range of 1000 – 1150 Kg/m^3.

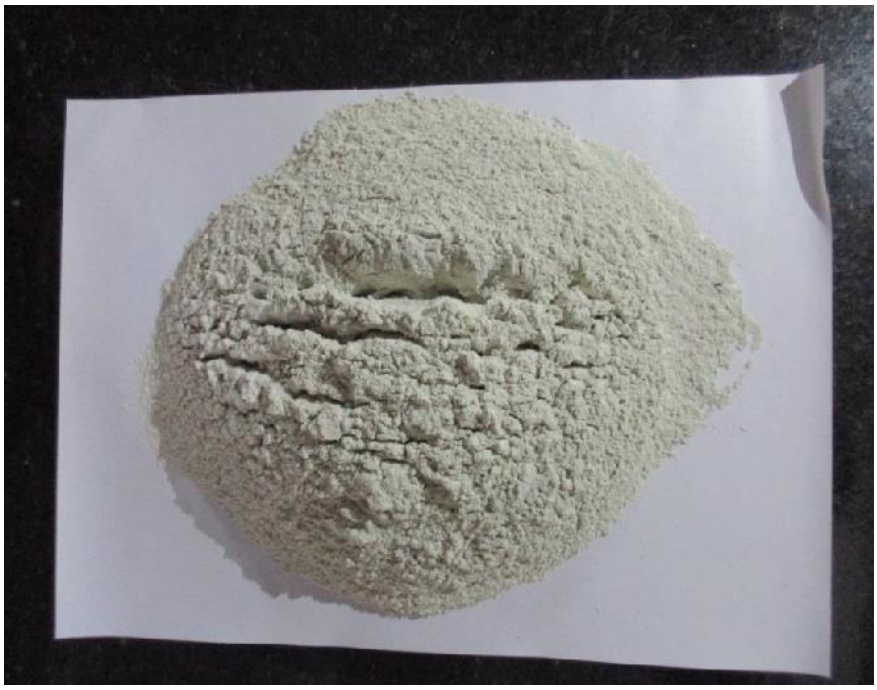


Fig 3. Wood Ash

Fig 4. Wood Ash Pellets

Mix proportion

Optimised mix design for semi-light weight concrete (slwc) using artificially made pellets is complicated task due to its high-water absorption capacity, porosity. After attempting several trial mixes in the laboratory, the final design mix proportion with a minimum cement content of 300 Kg/m^3 is shown below.

Cement: 300 Kg/m^3

Wood Ash pellets: 622.155 Kg/m^3

Sand: 1174.02 Kg/m^3

Water: 187 Kg/m^3

Super plasticiser: 4.5 Kg/m^3

HOW DOES IT WORK?

The density of concrete specimens (shown in figure 7) for the above designed mix proportion is between 2000 Kg/m^3– 2200 Kg/m^3. With a compressive strength of 23 to 25 MPa at 28^{th} day water curing which was achieved by 100% utilization of waste materials (wood ash aggregates) in concrete (shown in figure 8 which is equivalent to that of a typical M_{20} grade conventional cement concrete.

To enhance strength and durability, cement is replaced with alccofine (shown in figure 5) as 0%, 15%, 30%, 50%, 70%. Alccofine, a mineral admixture which contain low calcium silicate obtained from glass industries. The maximum compressive strength is found to be 38.7 MPa of 15% replacement mix at 28 days curing.

Fig 5. Alccofine

Rapid chloride penetration test (RCPT) (shown in figure 6) was conducted on 0%, 15%, 70% specimens to find the chloride ingression as per ASTM C1202. By increasing alccofine content, the

resistivity of slwc against chloride ions becomes high. The results (shown in table 1) are compared with permissible limits to find penetrability (given in table 2) given in ASTM C1202.

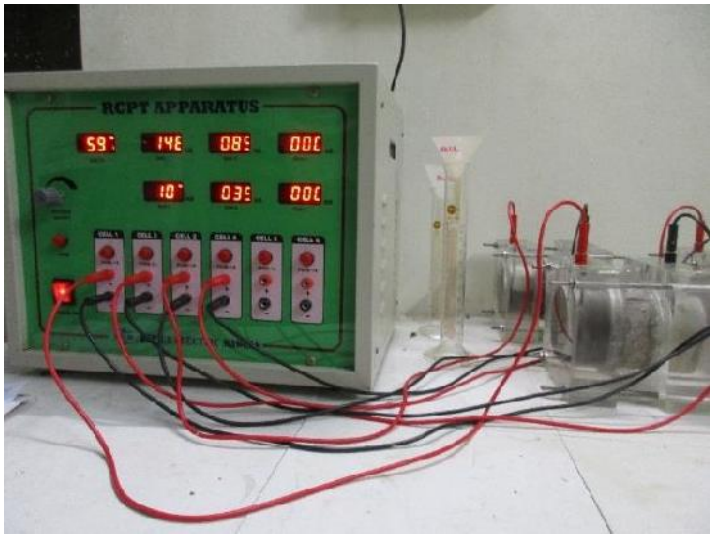


Fig 6. RCPT apparatus

Table 1. RCPT results

Alccofine %	Charge Passed (coulombs)	Chloride Ion Penetrability
0	2532.6	Moderate
15	1683	low
70	545.7	very Low

Table 2. Permissible Limits (ASTM C 1202)

Charge Passed(coulombs)	Chloride Ion Penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very Low
<100	Negligible

The presence of alkalinity was identified by applying Phenolphthalein indicator on fractured specimen; it turned to pink colour when compared with conventional concrete which remains colourless (shown in figure 9a & 9b). It should act as a protective layer on reinforcement against corrosion, etc.

Fig.7. Cube specimens

Fig 8. Fractured specimen

Fig 9a. Pink colour indicates the basic pH of (WAP) concrete

Fig 9b. Colour less indicates the acidic pH of Conventional concrete

Wood ash pellets act as an internal curing regime. Therefore the internal micro-structure of the concrete was hydrated well that leads to a strong formation of C-S-H gel which plays a great role in the strength and durability.

ADVANTAGES IN THE INDIAN SCENARIO.

- Structural light weight concrete has better fire resisting property compared to normal weight concrete.
- Lower coefficient of thermal expansion.
- Construction should be fast and easy needing less manpower.
- Transportation of material is very reliable.
- It reduces the self-weight of the structure.
- Footings and piles to be saved due to its significant weight reduction.
- Cutting, nailing, sawing, drilling of concrete is quite easier than normal and heavy weight concrete.
- It can be recommended for earthquake resistant structures due to its semi-light weight.

PRECAUTIONS IN USAGE:

Because of greater water absorption of wood ash pellets, it is highly recommended to test the water absorption of the pellets before employing the design mix, else it will lead to serious reduction in workability & strength of concrete as well as vulnerable plastic shrinkage cracks on the surface of concrete immediately after a few hours of concreting.

APPLICATION IN BUILDING, CONSTRUCTION AND INFRASTRUCTURE

Owing to its light weight capability, wood ash concrete can be used in light weight structures. It will reduce the overall dead weight of the structure. It has a good insulating property, good durability. It can be used in insulating panels, precast panels, sound proof walls, roofing panels, compound wall, partition walls, precast bricks, bridge decks. Due to its light weight, the size of columns, beams and other load bearing structures may be reduced. It is also suitable for earthquake prone areas.

COST, CHALLENGES AND AVAILABILITY

- Wood ash is abundantly available in the saw mills, dryers of modern rice mills at free of cost. In fact, semi-light weight concrete costs Rs 618/m^3 less than conventional concrete.
- Based on the experimental investigation/results, we recommend that the semi light weight wood ash pellets concrete shall be ideally used for constructing low cost housing. Our central government has started the scheme ‘Pradhan Mantri Awas Yojana’ (PMAY) to build a house for poor people in economical way. We suggest our semi-light weight concrete for ”homeless people to own their dream home” to build low cost housing.

APPLICATIONS OF NANO-TECHNOLOGY IN ENVIRONMENTAL ENGINEERING

Dr. R. N. Uma

Professor & Head, Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore-10

Wikipedia defines sewage as a type of wastewater that is produced from a community of people. It is characterized by volume or rate of flow, physical condition, chemical and toxic constituents, and its bacteriologic status (which organisms it contains and in what quantities). It consists mostly of greywater (from sinks, tubs, showers, dishwashers, and clothes washers), blackwater (the water used to flush toilets, combined with the human waste that it flushes away); soaps and detergents; and toilet paper (less so in regions where bidets are widely used instead of paper). About 38791 MLD of untreated sewage (62% of the total sewage) is discharged directly into nearby water bodies (CPCB, 2016). About 80% of water supplied (especially in urban areas) becomes wastewater. It is estimated that 22,900 MLD of domestic wastewater is generated from urban centres and 3,500 MLD of industrial wastewater is generated. However, it is estimated that less than 20% of domestic and 60% of industrial wastewater is treated. Metros and large cities (more than 100,000 inhabitants) are treating only about 29.2% of their wastewater; smaller cities treat only 3.7% of their wastewater. Key issues that influence wastewater management in India are High-tech (generation) low-tech (waste management) dilemmas; old concepts do not exist and new ideas in old environment – urban cycles.

A new directive on waste is being implemented to overcome the issues with wastewater management in India. Waste hierarchy such as Reduction (prevention of generation); Re-use; Recovery (recycling, composting, and energy) and Disposal of waste is recommended. Selection of appropriate technology for implementation of waste management is based on volume of waste, waste composition, market for secondary products if any authority & social priorities, volume of residual material (available landfill), investment & operational cost and new challenges

NANOTECHNOLOGY:

Nanotechnology has been considered as a promising alternative for waste management. Nanotechnology market is expected to grow to 1 trillion euros over the next 10 years. Nanotechnology has a potential for application in the fields of membrane filtration (drinking and wastewater), anti-microbial nanoparticles for disinfection and microbial control, removal of arsenic & heavy metals, and nanosensors for water quality monitoring. Nanotechnology is the study of the controlling of matter on an atomic and molecular scale. Generally it deals with structures sized between 1 to 100 nanometer in at least one dimension, and involves developing or modifying materials or devices within that size. At nanoscale, materials obey different lays of physics as they approach the atomic scale:

- Gold changes color in the nanoscale
- Zinc oxide appears clear
- Boiling temperatures change
- Gravitational forces become negligible
- Electromagnetic forces become dominant

Some of the environmental applications include Sensors, Water Treatment, Remediation (clean up sites), Green manufacturing, Green energy, etc.

NANOMATERIALS:

A nanometer (nm) is a billion part of meter, i.e., 10^{-9} m. Nanomaterials are materials with a dimension of 100 nm or less in at least one dimension, and nanoparticles are those that have at least two dimensions between 1 and 100 nm. Due to the presence of a large proportion of atoms on the surfaces of NPs, they allow significantly higher numbers of adsorption/reactions with the surrounding contaminants. This characteristic makes NPs more reactive than those materials with the same composition in macro-scale. Either a sheet of paper that is 100,000 nm thick or a strand of human hair that has dimensions about 1,000 times higher than an NP can be used as examples in order to get a better physical sense of the size of these nanomaterials.

The NMs can be classified as occurring naturally, accidentally, or deliberately manufactured.

1. Examples of naturally occurring NMs include clay, organic matter, and iron oxide; all of which are part of the soil composition.
2. Accidentally generated through air emissions, solid or liquid wastes from production facilities for nanoscale materials, agricultural operations, fuel burning, and weathering
3. The nanomaterials manufactured are either synthesized or developed with features aimed at improving their application in a technological or industrial purpose.

The NMs can be produced in a variety of ways, and they are grouped mainly into two technologies. The first technology is from top to bottom or from outside to inside (top down), where part of something bigger (bulk material) is turning into something smaller. The second is a technology called bottom to top (bottom-up), where small things will build something bigger. Most top-down technologies involve methods such as milling, friction, heating, and photolithography. Bottom-up technologies involve molecular components such as raw materials connected with chemical reactions, nucleation, and growth process to promote the formation of more complex clusters. The NMs manufactured are designed with specific properties and can enter the environment through industrial or environmental applications, such as their use for remediation of soils and groundwater for example

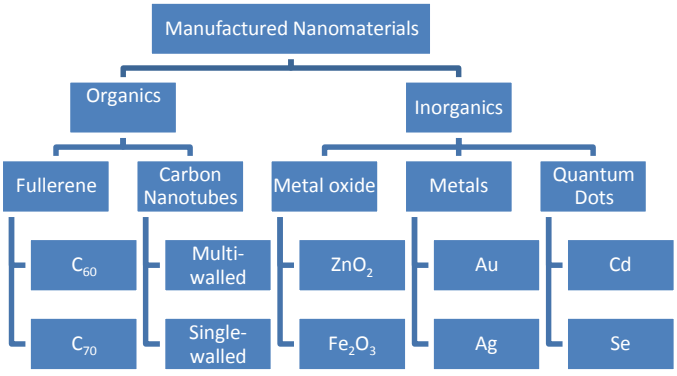


Figure 1. Classification of nanomaterials according to physical–chemical properties

APPLICATIONS OF NANOTECHNOLOGY:

Nanotechnology in wastewater treatment is beneficial because it presents a economical, convenient and eco-friendly means of wastewater treatment. Toxin and contaminant's levels vary with geographical variations but nanotechnology based sensors provide a wide range of sensitivity making it applicable in all kind of geological conditions and contamination types.

Nanotechnology can improve the desalination abilities of filtration membranes which can provide potable water at substantially low cost from brackish water or sea water. It has a potential to treat acid mine drainage and other industrial effluents at very low cost. Remediating environmental damages is feasible using nanomaterials.

Soils and groundwater are contaminated by toxic pollutants from either natural or anthropogenic sources at concentrations capable of posing great risk to human health and the environment. The problems of contaminated soils have raised great concern among environmental agencies due to the existence of a large number of polluted sites, mainly in urban and industrialized areas.

There are many available technologies for the remediation of contaminated soils and groundwater, which can be classified into: (1) ex-situ technologies, in which the contaminated soils or groundwater (or both) must be removed from the site and treated on-site or off-site, and (2) in-situ technologies, in which the contaminated soils or groundwater (or both) are treated directly within the subsurface. The use of in-situ treatment technologies is often preferred because of the major technical and economic advantages over ex-situ technologies. Technologies that utilize nanoparticles (NPs) for remediation of contaminated sites have been rapidly developed in recent years. The majority of these studies are being carried out on bench scale. However, a few studies have reported the use of NPs at field scale.

NANOPARTICLES AND ENVIRONMENTAL REMEDIATION:

Environmental protection and pollution represents crucial worldwide issues that need to be addressed at the earliest possibility. The numbers of landfills, oil fields, military installations, private properties, manufacturing and industrial contaminated sites are staggering, globally. Traces of pesticides, oil and greases, heavy metals and other toxic chemicals together with high chloride concentrations and low dissolved oxygen levels (0.75mg/L) in water aquifers were recently reported by Jadhav et al. (2013). Leachate produced by a municipal solid waste landfill sites had reported to have had a profound impact on surrounding shallow basaltic aquifers where physio-chemical parameters for groundwater reported high concentrations of heavy metals including Al, Cd, Cr, Fe, Zn, Ni and Pb in water. Following the recent successful trend of using these biological systems including bioremediation, phytoremediation and rhizoremediation, nanotechnology has recently been applied to environmental remediation (termed nanoremediation).

Nanoremediation is now striving to provide a new and effective solution for environmental clean-up by playing a significant role in pollution prevention, detection,

monitoring and remediation. Nanoremediation using nanoscale particles or nanomaterials holds significant potential to cost-effectively address some of the challenges of site remediation and improve the overall efficiency of the remediation processes. Current expensive, tedious and partially effective soil and groundwater remediation technologies such as thermal treatment, chemical oxidation and surfactant cosolvent flushing could be slowly phased out over the coming decades with arrival of the rapid, inexpensive and efficient nanoremediation approaches. While significant financial investment has been made to the clean-up of contaminated soil, water and other environmental media, the aggregated financial burden for site clean-up is high.

Jadhav, S.D., Jadhav, M.S., Jawale, R.W., 2013. Study of chloride and nitrate concentration of Mula Mutha River in Pune city (Maharashtra). Int J Chem Life Sci 2, 1140–1142.

Nanoremediation methods entail the application of reactive NMs such as nanoscale zeolites, metal oxides, carbon nanotubes and fibers, bimetallic nanoparticles etc. for the transformation and detoxification of pollutants. Of these, nanoscale zero-valent iron (nZVI) is currently the most widely used. The high surface area associated with their high reactivity makes them an excellent agent, capable of transforming or degrading contaminants in soils and water. The other key factors favoring nZVI's include; low standard reduction potential, favorable quantum size properties and potential increase in transport efficiency through groundwater's underground matrix. These NMs have properties that enable both chemical reduction and catalysis to mitigate a variety of pollutants of concern including chlorinated compounds, organochloride pesticides, polychlorinated biphenyls, heavy metal ions and inorganic anions. In the majority of contaminated sources, nZVI's are likely to be transformed from Fe^0 to Fe^{2+} and then may undergo further oxidative transformation to Fe^{3+}.

The dominant means of groundwater and surface water corrosion for nZVI can be explained by the following equation:

$$2Fe^0(s) + 2H_2O(l) \rightarrow 2Fe^{2+} + H_2(g) + 2OH^-.$$

The resulting Fe^{2+} can be further transformed to the stable Fe^{3+} ion by either of the following oxidative transformations:

$$2Fe^{2+}(s) + 2H^+(aq) + O_2(aq) \rightarrow 2Fe^{3+} + H_2O(l)$$

$$2Fe^{2+}(s) + 2H_2O(l) \rightarrow 2Fe^{3+} + H_2(g) + 2OH^-(aq)$$

Fe^{2+} has been shown to be the most toxic state of iron for microorganisms and invertebrates but will rapidly convert to Fe^{3+} under neutral and alkaline environments. In deep underground aquifers where oxygen is limited, Fe0 is likely to be converted into either magnetite (Fe_3O_4) and/or maghemite (Fe_2O_3, γ-Fe_2O_3) depending on oxidation conditions.

nZVI been used for removal of heavy metals like arsenic and chromium; pesticides (lindane, DDT); chlorinated solvents (PCE, TCE, DCE) and for transformation of organic compounds like nitrates. Considering the advantages offered by this technique, E-nano is becoming widely adopted for a variety of environmental applications like soil, water and groundwater remediation, oil spill decontamination, wastewater treatments and water purification. A synopsis of the applications of variety of NMs for environmental clean-up is presented in below.

Case studies showing successful applications of variety of nanomaterial (NMs) for groundwater, water and soil remediation.

Contaminated sources	Contaminants	Applied treatments	Type of study	Success rate
Groundwater	Chlorinated compounds (PCE, TCE, DCE)	Injection of nZVI in subsurface	Field	96% TCE reduction over 4 weeks
		nZVI Flakes	Lab + Field	PCE reduced from 20,000–30,000 to 100–200 μg/L 80% TCE dechlorination/day
		Bimetallic particles (Pd/Fe)	Laboratory	
	Heavy metals (Pd, Cr, Cu)	ZVI	Lab + Field	~95%–99% removal
	As (III), As (V)	nZVI reduced graphite oxide modified composites	Laboratory	Water quality observed within standard WHO guidelines
	Hexachlorobenzene	Bimetallic particles (Ag/Fe)	Laboratory	Degraded to byproducts within 2 h
Water	Explosive compounds	Ni/Fe; Cu/Fe	Laboratory	Immediate degradation was observed
	Nitrates, Cations, Natural organic matter, biological contaminants	Titanium dioxide nanomembranes	Lab + Pilot studies	High success rate in all studies observed
	Hexavalent Chromium Cr(VI)	Agarose stabilized nZVI (A-nZVI)	Laboratory	100% Cr(VI) removal
		Natural and synthetic goethite ZVI (NG/SG-ZVI)	Laboratory	99% removal rate
	Metal Ions (Cd^{2+}, Pb^{2+}, Hg^{2+}, AS^{3+})	Core–shell nano-composites of silica–gold (SiO_2-@Au)	Lab + Pilot studies	Easy detection and removal of metal ions
	Zn^{2+}	ZVI	Experimental conditions	85% removal within 2 h of treatment
Wastewater	Organic compounds (dyes, pesticides, pharmaceuticals/drugs)	Carbon Nanotubes	Lab + Pilot Studies	~100% removal/degradation
	Arsenic, Phenol	ZVI	Laboratory	High removal efficiencies reported
	Activated sludge	ZVI	Laboratory	Increased protein degradation rate with increased VFA production observed
Crude Oil Spill	Hydrocarbons	Superhydrophobic nanomembrane and oleophilic graphite nanoplatelets	Laboratory	Good results including its recyclability were observed
		Nano-sized calcium oxides	Pilot Study	
Soil	Bisphenol A, Cu^{+}	Magnetic hybrid nanoparticles modified with β-Cyclodextrin	Laboratory	Efficient and non-toxic way of removal was reported

RISKS ASSOCIATED WITH THE USE OF NANOPARTICLES:

The major environmental concern is that the tiny nanoparticles could end up in environmental bodies infesting drinking water sources harming the health of humans and animals. Nanoparticles present potential risks in terms of

(i) dispersal—ability to disperse in the environment including potential long range transport;
(ii) ecotoxicity—ability to cause adverse effects to organisms in the environment;
(iii) persistency—ability to remain in the environment;
(iv) bioaccumulation—ability to bioaccumulate or bioconcentrate in higher order organisms and;
(v) reversibility—ability for removal or to reverse their original introduction from environment.

Although nanotechnology is likely to represent a beneficial replacement of current practices for site remediation, research into health and environmental effects of nanoparticles is urgently required.

IMPROVEMENT METHODS OF WEAK SOILS

Dr. S.P. JEYAPRIYA
Assistant Professor
Government College of Technology
Coimbatore

THE NEED

When a Project encounters difficult situation,

What will we do?

THE POSSIBLE SOLUTIONS ARE....

Avoid particular site

Design the planned structure accordingly

Foundation supported by piles

Remove and replace the soil

Enabling cost effective foundation design

Attempt to modify the existing ground- and that is Ground improvement

GROUND IMPROVEMENT

The process in which in-situ soils are improved for the support of the foundations in known as ground improvement.

Ground Improvement refers to a technique that improves the engineering properties of the soil mass treated.

Usually, the properties that are modified are shear strength, stiffness and permeability.

TYPES OF GROUND CONDITIONS

Poor Ground Conditions

Expansive Clays-Volume change behaviour

Soft Clays-low bearing capacity and highly sensitive to disturbance

Organic soils-highly compressible in nature

Loose sands-undergo large settlement

Loess- Collapse on saturation

TYPES OF GROUND CONDITIONS

Favourable Ground Conditions

Cohesionless granular soils (medium dense to dense sands)

Cohesive granular soils (Sandy- clay mixture)

SDR (Silty Sand)

CLASSIFICATION OF GROUND IMPROVEMENT

Mechanical Modification-application of force to increase the density.

Hydraulic Modification-removal of pore water from soils.

Physical and Chemical modification-stabilization process.

Modification by Inclusions and confinement-fibres/bars/meshes/fabrics etc that imparts tensile strength to soil.

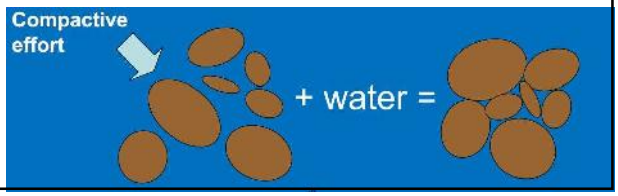
COMPACTION

The Objective is.....

Soil densification-reducing voids and increasing the density by compaction.

Added benefits are

- Increase in shear strength
- Reduction in permeability
- Reduction in Compressibility
- Reduction in liquefaction Potential
- Control in Swelling and Shrinkage



METHODS OF COMPACTION

Static Compaction-compressing known volume of soil by applying compressive force.

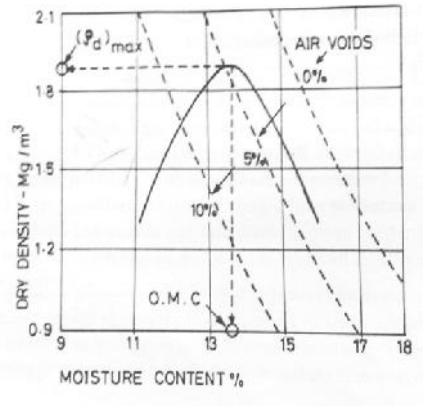
The primary controlling factors are

a)Moisture content

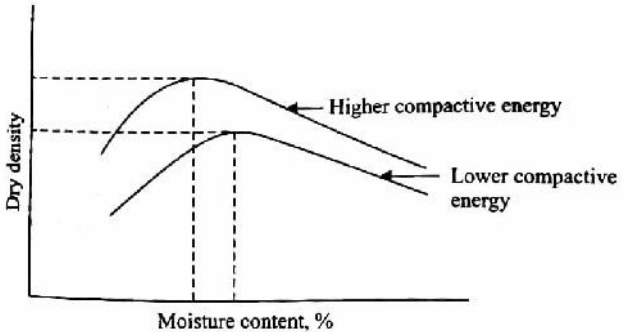
b) Compactive Effort

c) Soil types

Moisture content-Moisture-Density relationship



Compactive Effort



Soil Types

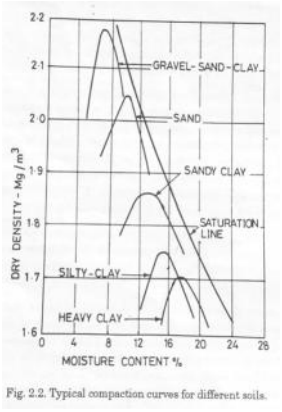


Fig. 2.2. Typical compaction curves for different soils.

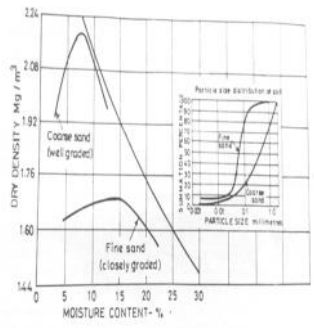


Fig. 2.3. Dry-density Vs Moisture content curves for two grades of sands (Adopted from HMSO, 1974)

METHODS OF COMPACTION – Contd...

Kneading Compaction-Calibrated spring loaded piston forced down into the soil.

Dynamic Compaction-blows given to soil by rammers dropping from a specified height.

(1. Both Standard and Modified Proctor Test &

2. Automatic Compaction apparatus)

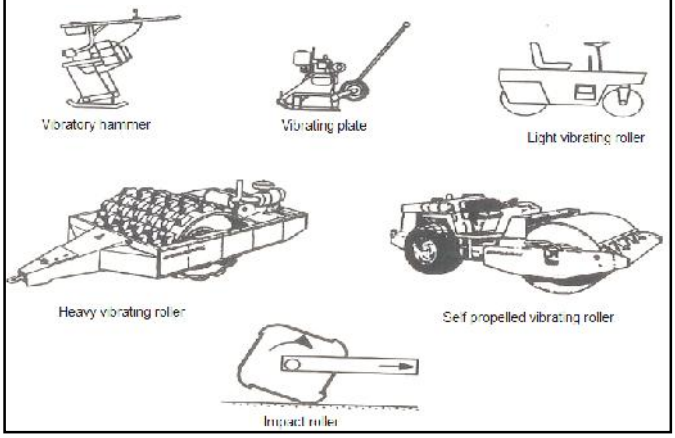
Shallow Surface Compaction

Cohesionless Soil-equipment working on the principle of vibration, tamping and kneading are effective.

Cohesive Soil-Tamping, kneading and Impact

- Surface Compaction Equipment
- Smooth wheeled rollers
- Pneumatic tired rollers
- Sheepfoot rollers
- Grid rollers
- Vibrating Rollers
- Impact Rollers

Shallow Surface Compaction



Smooth Wheeled Roller

Consists of three wheels – two in the rear & one in the front.

Mass varies from 2 to 15 Mg.

Compacts effectively only to 200-300 mm of soil from the surface.

Used for finishing operations and compacting granular base course.

Pneumatic Tyred Roller

Uses compressed air for inflation pressure.

9 to 11 wheels fixed on two axles

Mass varies from 5 to 200 Mg.

Compacts by kneading action.

Effective for cohesive and cohesionless soils.

Compacts upto 30cm thickness.

Sheep foot roller

Consists of hollow drum with large number of projections.

These projections penetrate the soil layers during rolling operation and cause compaction.

Ideally suited for cohesive soils.

Provides kneading action called "walking out" of the roller.

Compaction depth is 5cm more than the length of projection.

Vibratory compactors

Compaction induced by vibrations.

They can be form of roller and plates.

Used in granular soils.

Compacts upto a thickness of 30 cm.

Roller Types

Grid Rollers

Vibrating Rollers

Impact Rollers

Deep Compaction Techniques

Deep Compaction Techniques

- Pre-Compression or Preloading
- Explosion
- Heavy Tamping
- Vibration
- Compaction Grouting
- Vibro-Compaction and Vibro-replacement

DEWATERING

DEWATERING

Process of removal of water from a foundation pit situated below the ground water table is known as dewatering.

It is also referred as sub-surface drainage.

PURPOSE

Keep excavations dry for concreting.

Improving properties of soil.

Reduction in hydrostatic pressure.

COMMON DEWATERING METHODS

Open sumps and ditches

Well point system

Deep well drainage

Vacuum dewatering systems

Dewatering by Electro-osmosis

OPEN SUMPS AND DITCHES

Open sumps and ditches are frequently used to remove surface water and a small infiltration of groundwater.

Handle minor amount of water inflow.

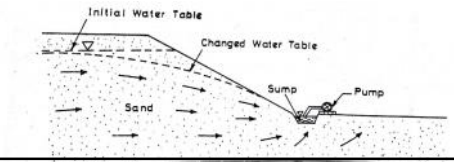
Most widely used method and economical.

More appropriate in presence of boulders or other massive obstructions.

Water table can be lowered to a maximum depth of 8m.

In granular soils, it is important that fine particles are not carried away by pumping.

Hence the sump may be lined with a filter material to prevent or minimize loss of fines.



WELL POINT SYSTEM

Small well screens of 50-80mm diameter and 0.3 to 1m length made of brass or stainless-steel.

Commonly used method for dewatering purposes and more effective in sands and gravels.

Well points are installed by jetting them into the ground.

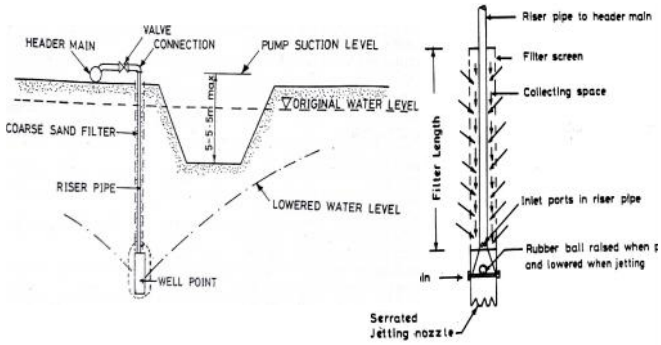
The capacity of a single well point of 50 mm diameter is 10 litres/min.

Spacing of well points depends on the type of soil.

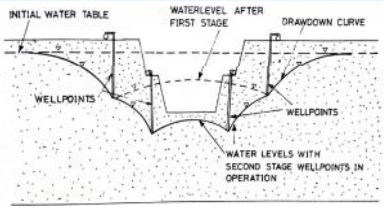
Well points are installed as

- Single stage
- Multi stage
- In braced excavations.

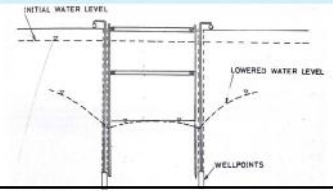
SINGLE STAGE WELL POINT SYSTEM



Multistage Well Point



Well Points in Braced Excavation



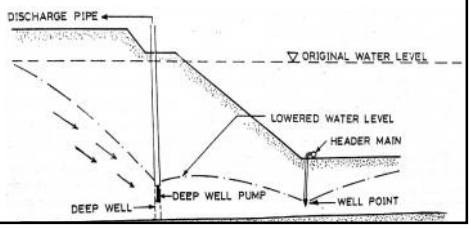
DEEP WELL DRAINAGE

Consists of deep wells and submersible or turbine pumps installed outside the zone of lowering water.

Usually spaced from 8-80m depending on the level of lowering water table, stratum and submergence.

Pumps are placed at the bottom of the wells and the water is discharged through a pipe connected to the pump.

They are more powerful than well points, require a wider spacing and fewer well holes.



VACUUM DEWATERING SYSTEM

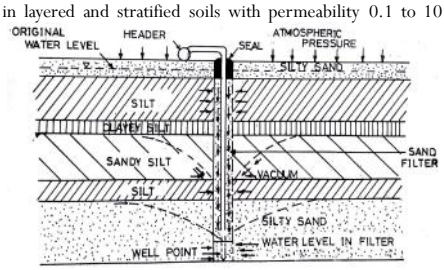
Used where gravity methods (well points & deep wells) are not effective in case of fine grained soils.

It requires well or well point screens, riser pipe surrounded with filter sand.

Water is dewatered by applying vacuum to the piping system.

A suction pump is used in this system where a maximum lift of about 3 to 6m can be achieved.

Most suitable in layered and stratified soils with permeability 0.1 to 10 x 10^{-4} cm/sec.



ELECTRO - OSMOSIS

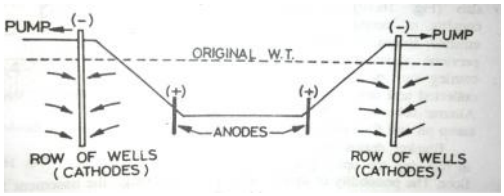
Electro motive force is applied between the two electrodes in a soil medium where the water molecules are attracted to the cathode.

By making a cathode well, water can be collected in the well and then pumped out.

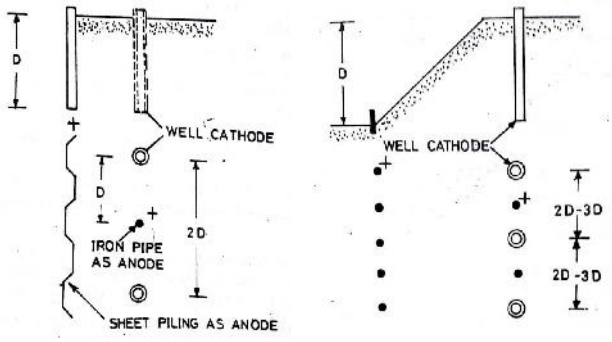
The electro osmotic flow is given by the expression, $Q=k_e i_e A$

The layout of electrodes depends on the intended purpose. Sheet piles are used as electrodes.

Electrodes can be single or in groups of two or three.



ELECTRO - OSMOSIS



Sheeted excavation Slopes

Electrode arrangement

SUITABILITY OF DEWATERING METHOD

Sl. No.	Method	Suitability
1.	Sump pumping	Gravel and coarse sand
2.	Well point system	Sandy gravels to fine sands
3.	Deep well drainage	Gravels to silty fine sand and water bearing rocks
4.	Vacuum dewatering	Fine grained and stratified soils
5.	Electro- osmosis	Silts, silty clays and some peats.

COMPRESSION AND CONSOLIDATION

What is Compression?

Compression of Soil is due to compressive stress

Compression is attributed to

- Rearrangement of Particles
- Seepage of Water
- Crushing of Particles
- Elastic distortions

When this Phenomena takes place in saturated clays-It is Consolidation

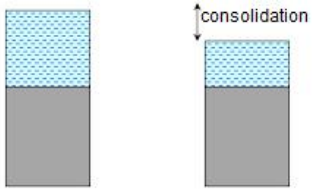
What is Consolidation?

Consolidation is the process which involves a decrease in water content of saturated soil without replacement of water by air.

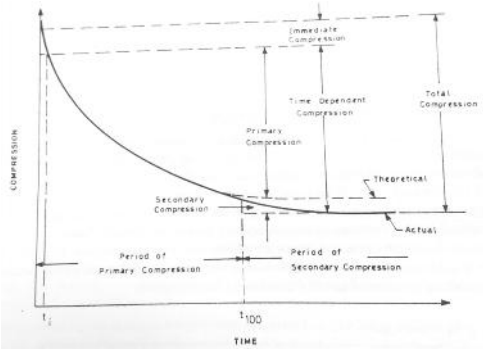
In general it is the process in which reduction in volume takes place by expulsion of water under long term static loads.

Consolidation occurs in 3 stages:

- Initial consolidation
- Primary consolidation
- Secondary consolidation



Components of total compression



PRELOADING

PRELOADING

Preloading is application of external loading for a long duration to cause desirable changes in the soil.

Also termed as pre-compression or surcharging, used in soft clays and silts.

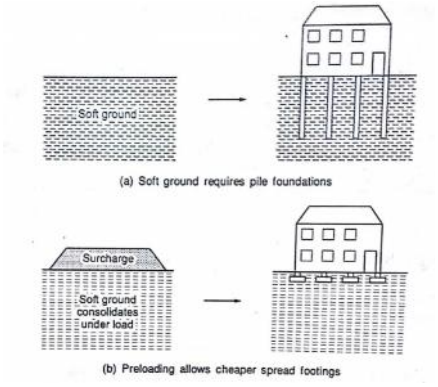
Heaping of fill materials is the most common method of preloading.

The ratio of weight used for preloading to the weight of final structure on the improved soil is called coefficient of surcharge 'm'. 'm' varies from 1 to 2 and deciding 'm' is the most vital choice.

The surcharge fill is kept on the ground for long time to cause consolidation.

Surcharge height varies from 3 to 10m and should extend atleast by 10m on all sides.

PRELOADING



VERTICAL DRAINS

VERTICAL DRAINS

Vertical drains are continuous vertical columns of pervious materials installed in clayey soils to accelerate settlement and hence time for consolidation reduces.

Provides pathway for the pore water to escape by travelling a shorter distance.

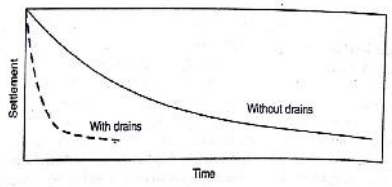
They allow the flow inside the soil to take place along the horizontal which is the direction of least resistance.

Vertical Drains–Why it is required?

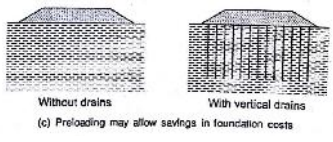
Preloading alone is insufficient particularly when the layer of soft clay is very thick.

Because of very low permeability it takes long time to bring about significant compressions.

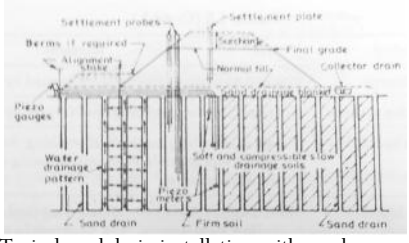
When vertical drains are placed in conjunction with preloading it speed up the settlement process.



Vertical Drains–Contd...



(c) Preloading may allow savings in foundation costs



Typical sand drain installation with surcharge

Types of Vertical Drains

Vertical drains are provided in the form of cylindrical hole filled with permeable material.

1) Sand
2) Geo-synthetic or Wick drains

Sand Drains - Formation

Holes are made by Augering-sand drains have diameters ranging between 200 to 450mm.

Spacing varies between 2.5m to 5m.

Uniformly graded sand with no fines should be selected.

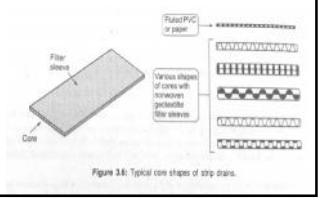
Wick Drains - Formation

Also known as PVD's –Band shaped products consisting of geotextile jacket surrounding a plastic core.

This structure permits pore water in the soil to seep into the drain for collection and transmittal up and down the length of the core.

Size is typically 100mm width and 3 to 9mm thickness.

First synthetic drains were developed by Swedish Geotechnical Institute.



Types of Wick Drains

Type	Core Material	Filter Material	Dimensions (mm)
Kjellmann	Paper	Paper	100 x 3
PVC	PVC	None	100 x 2
Geodrain	PE	Cellulose	95 x 4
Mebradrain	PP	PP or PES	95x 3
Alidrain	PE	PES	100 x 6
Colbond	PES	PES	100 x 6
Hitek	PE	PP	100 x 6

Advantages of Wick Drains

1. Economy
2. Ease of installation
3. Assured Continuity
4. Minimal displacement
5. Improved quality control
6. Equipment flexibility
7. Less material storage required
8. No spoil removal involved

VIBRATION

VIBRATION TECHNIQUES

Vibration-Inertia forces become significant in comparison to static forces to bring deformation and displacement resulting in densification.

Suitability-Cohesionless soil

VIBRO-COMPACTION

Rapid method of densification and effective in saturated cohesionless soils

Improvement is due to reorientation of grains

The new density or compactness attained is permanent and not reversible.

METHODS-Blasting, Vibratory Probe and Vibratory Compactors

BLASTING

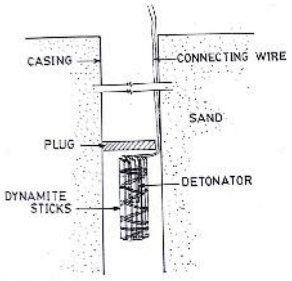
BLASTING

Pipe of 7.5cm to 10cm is driven to required depth in the soil strata.

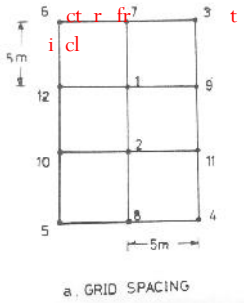
Dynamite sticks and an electric detonator is wrapped in water proof bundles and lowered into the soil.

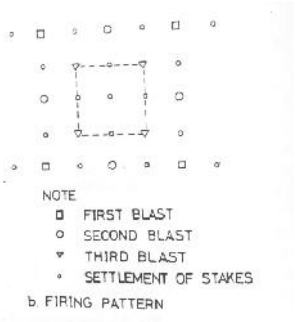
Casing is withdrawn and the hole is backfilled with sand.

The electrical circuit is closed and the charge is fired.



Spacing and Pattern of Blasting





VIBRATORY PROBE

VIBRATORY PROBE

Also called as Terra Probe consists of a vibrodriver coupled to an open-ended steel tubular probe.

The terra probe consists of an open ended pipe about 75cm diameter and 15m length.

Vibrodriver activates the probe to vibrate in the vertical direction and imparts vertical impulse.

This vibration allows the vertical pipe to penetrate into the loose soil.

The probe is sunk to the desired depth and held for 30 to 60 seconds.

VIBRATORY PROBE

In each insertion, the probe densifies a cylinder of soil of 1m diameter and 1m deeper than the probe location.

Advantages

Does not require backfilling

Cost is moderate

Considerably faster than other techniques

Suitable for offshore locations

VIBRATORY COMPACTORS

VIBRATORY COMPACTORS

Available as

- Vibrating drums
- Vibrating pneumatic – tire
- Vibrating plate equipment

They are operated with frequency range 1500 to 2500 cpm which is natural frequency range of most of the soils. Compacting at Natural frequency gives maximum effect resulting in dense arrangement.

VIBRATORY COMPACTORS

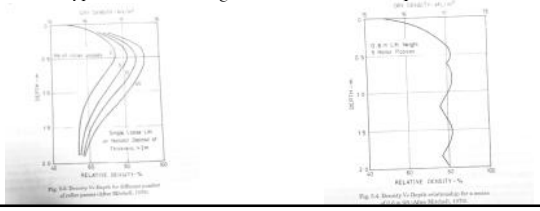
Heaviest vibratory rollers can densify soil upto 2m depth.

Parameters considered for Compaction process

Lift Thickness-High thickness results in loose density and low thickness cause waste of energy.

Roller type

Soil Type-Cohesive soil gives resistance to compaction



DYNAMIC COMPACTION

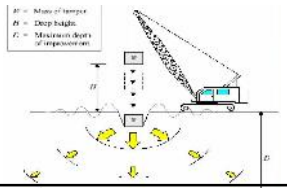
DYNAMIC COMPACTION

Also termed as dynamic consolidation, heavy tamping or pounding.

A heavy weight of 2 to 50 tonnes (called pounder) is dropped on the ground from a height of 7 to 35m repeatedly from a crane.

The pounder is of concrete or steel block which is lifted and made to drop freely under gravity.

At each point, 5 to 10 poundings are given where a pit or crator is formed which is to be levelled after pounding operation.



DYNAMIC COMPACTION

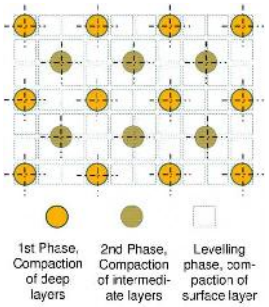
Effective for compaction of loose sands and silty soils.

Can also be used for compacting soil containing boulders, land fills, liquefaction prone sand and collapsible soils.

Good densification can be achieved upto a depth of 5 to 10m.

Due to shock waves, it cannot be used near existing structures.

DYNAMIC COMPACTION

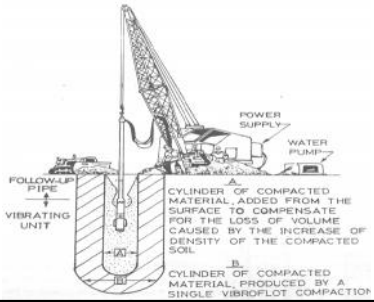


VIBROFLOTATION

VIBRO FLOTATION

Vibroflotation equipment consists of

Vibroflot probe with accessories like power supply, water pump and front-end loader.

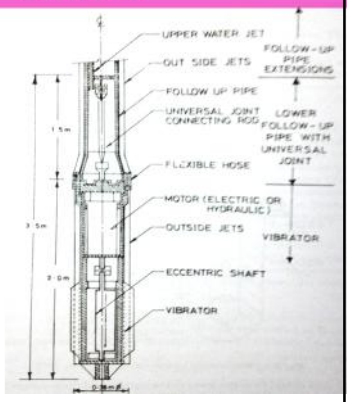


VIBRO FLOTATION

Vibroflot Probe consists of two parts

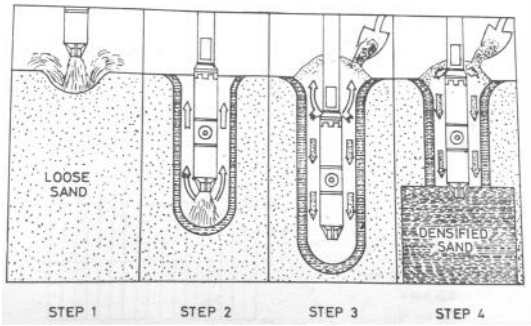
The lower part consists of vibrating unit and

The upper part is a follow-up pipe-the length can be varied depending upon the depth of compaction



Vibroflotation - Compaction process

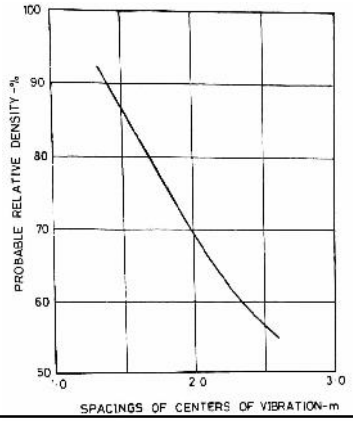
Each compaction sequence has four steps.



Vibroflotation - Patterns and Spacings

Square Footing Size (m)	Number of vibroflotation points	Centre to centre spacing (m)	Pattern
<1.20	1	-	-
1.40 to 1.70	2	1.80	Line
1.80 to 2.10	3	2.30	Triangle
2.30 to 2.90	4	1.80	Square
3.00 to 3.50	5	2.30	Square + one at centre

Relationship between relative density and spacing



Backfill Material Rating

Rating is based on Suitability Number

$$\text{Suitability Number} = 1.7\sqrt{\frac{3}{(D_{60})^2}+\frac{1}{(D_{30})^2}+\frac{1}{(D_{10})^2}}$$

Backfill Evaluation Criteria

Suitability Number	Description of Rating
0 to 10	Excellent
10 to 20	Good
20 to 30	Fair
30 to 50	Poor
>50	Unsuitable

Merits of Vibroflotation Technique

1) No material cost except backfill material

2) Complete uniformity in density

3) Gives higher bearing capacity

4) Much quicker in operation

SAND COMPACTION PILES

SAND COMPACTION PILES

Driving hollow steel pipe to the desired depth using impact hammer or vibratory driver.

Sand is introduced in lifts.

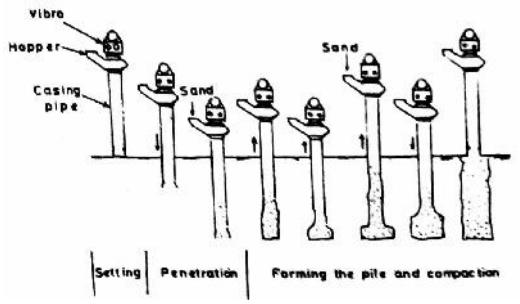
Each lift is compacted concurrently with withdrawal of pipe.

Compressed air is blown down inside the casing to hold the sand in place.

The in-situ soil is densified thus preventing collapsing of the surrounding soil.

The compacted soil also expands laterally below the tip forming a caisson pile.

SAND COMPACTION PILES



Vibro-composer method

STONE COLUMNS

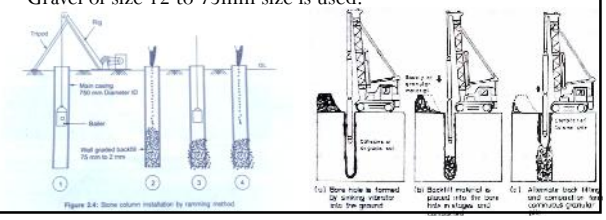
STONE COLUMNS

Also known as granular piles installed using vibration Techniques.

Cylindrical hole is formed and backfilled with backfill.

Formation of stone column by Vibrofloat technique is very common in improving cohesive soil.

Gravel of size 12 to 75mm size is used.



STONE COLUMNS

Suitable for soft inorganic clays inorder to increase the bearing capacity and with significant reduction in settlement.

It serves two basic functions:

- Providing reinforcement to the soil
- Acting as vertical drains to allow quicker consolidation.

Length of the stone column should extend below significant depth.

Resistance is derived from perimeter shear and not by end-bearing.

Load carrying capacity of stone column is controlled by the passive resistance (withstand lateral bulging) of the soft soil that can be mobilised and on the friction angle of the gravels used.

Important Criteria:

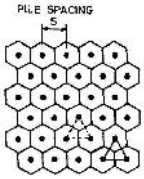
Bearing Capacity of stone column is generally high and hence settlement criteria is important in design aspects.

Stone Columns - Design Parameters

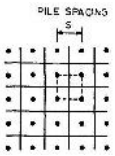
Stone Column Diameter

Diameter usually varies from 0.45 to 1.2m

Pattern of arrangement



Triangular pattern of arrangement



Square pattern of arrangement

Stone Columns - Design Parameters

Spacing

Column spacing depends upon the site conditions, loading pattern, column factors, installation technique, settlement reduction. Centre to centre spacing varies from 1.5m to 3.5m.

Area replacement ratio

Soil replaced by the stones is termed as area replacement ratio 'a_s' . It should vary from 0.1 to 0.4.

$a_s = A_s/A$

Where

A_s is the area of stone column after compaction

A is the total area to be improved

SOIL REINFORCEMENT

Soil Reinforcement

Concept of Reinforcement was introduced by Henry Vidal.

Insertion of tensile elements like bars/rods/nails to resist the pullout forces in soils.

Soil reinforcement involves in stress transfer all along the reinforcing element.

Interaction between soil and reinforcing element is solely by friction.

MECHANICALLY STABILIZED EARTH (MSE)

Mechanically stabilized earth or MSE is soil constructed with artificial reinforcing. It can be used for retaining walls, bridge abutments, seawalls, and dikes.

The reinforcing elements used can vary, includes steel and geosynthetics.

Three basic components of reinforced earth wall are:

Backfill material (local soil, specified soil)

Reinforcing element (strip, grid or sheet, fabricated from metals or geosynthetics)

Facing units to prevent soil from erosion (precast concrete panels, metal sheets, shotcrete or wrapped sheets of geosynthetics).

Features of MSE

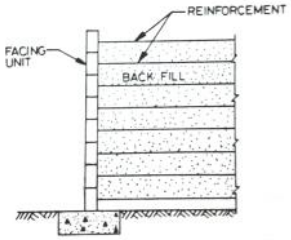
Strength : Resists significant earth pressure and seismic force.

Flexibility : It adapts to foundation soils and large settlements.

Construction : Easily constructible by untrained labour

Low Costs

Aesthetic factors : Good appearance as facing can be attractive.



SOIL NAILING

Soil nails are rigid bars which are driven into the soil and filled with grout.

The direction of soil nails is flexible to maximize their reinforcing effect.

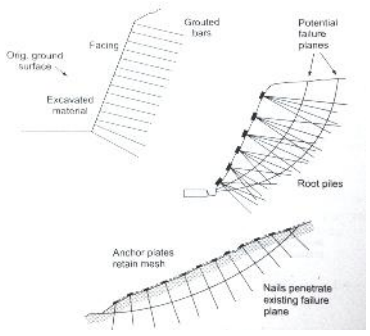
Nails can be of thin steel bars to light concrete piles.

The fundamental concept of soil nailing consists of reinforcing the ground by passive inclusions.

It helps in increasing the overall shear strength of the in-situ soil and restrain its displacements.

The use of smaller diameter piles of 0.1m are nailed to soil called as root piles and micropiles of diameter 0.25m.

SOIL NAILING

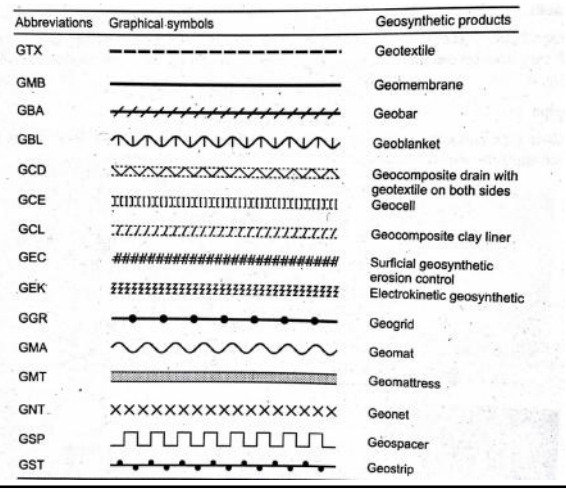


GEOSYNTHESIS

Geosynthetics are made from polymeric materials which when used in contact with soil, rock or any other related materials help in serving its purpose.

Most common forms of geosynthetics are:

- Geotextiles
- Geogrids
- Geonets
- Geomembranes
- Geocomposites



FUNCTION	DESCRIPTION	TYPE OF GEOSYNTHETICS
Filtration	Allow the passage of fluids preventing the migration of soil particles	Geotextiles, geocomposites
Drainage	Transport of fluids by dissipating excess pore water pressure	Geonets, geocomposites
Separation	Prevents the mixing of two different soils or materials	Geotextiles, geocomposites
Protection	Avoid damages to a structure, a material or another geosynthetic	Nonwoven geotextiles, geonets, geocomposites
Reinforcement	Provides tensile strength of soil, fatique resistance and increases the bearing capacity.	Geogrids and geotextiles
Fluid barrier	Impermeable membrane to prevent the passage of liquids and gases	Geomats, geomembranes
Confinement	Restrain the lateral movement of a soil mass	Geocell

SOIL STABILIZATION

SOIL STABILIZATION

Soil stabilization is referred as a procedure in which a special soil is proportioned/added/ removed, cementing material or other chemicals are added to natural soil to improve one or more of its properties.

Most common method of stabilization includes mixing of natural coarse grained and fine grained soil.

Objective

- Adequate strength.
- Reduction in compressibility.
- Control swell-shrink behaviour.
- Reduction in permeability.

METHODS OF STABILIZATION

Mechanical stabilization

Cementing stabilization

Chemical stabilization

Electrical stabilization

Stabilization by thermal and freezing techniques

MECHANICAL STABILIZATION

Also known as granular stabilization. Process of improving properties of soil by changing its gradation.

Mechanical stabilization involves two ways to improve the soil:

- Rearrangement of soil particles.
- Improvement of soil gradation.

Weak aggregates are preferred which can break down under compaction producing maximum dry density.

It involves two steps:

- Proportioning the materials
- Addition or removal of soil particles.

CEMENTING STABILIZATION

Binding of soil particles together without any other alteration is referred as cementing stabilization of soil.

Cement and bitumen addition causes cementing stabilization of soil.

Portland cement is most successfully used soil stabilization in which cement reacts with the siliceous soil to bind the particles together which is referred as soil-cement.

Bituminous materials like bitumen, asphalt and tar are used which stabilizes the soil by binding the particles in cohesionless soils and protecting the soil from deleterious effects of water in cohesive soil or both.

Depends on factors like:

Nature of soil, amount of cementing material, mixing, compaction and curing conditions and admixtures.

CHEMICAL STABILIZATION

It is bonding the soil particles with a cementing agent that is produced by a chemical reaction within the soil on addition of a primary chemical additive.

The primary additives widely used are:

Lime : Hydrated limed (slaked lime) is commonly used. Used to improve soft and expansive soils. The soil-lime reactions are:

Cation-exchange

Flocculation

Aggregation

Salts : Calcium and sodium chlorides react similarly as soil stabilizers by causing changes in the characteristics of water present in the soil pores.

CHEMICAL STABILIZATION

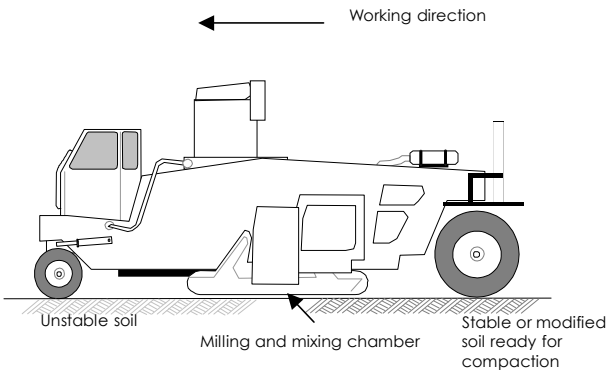
Lignin : Forms an insoluble gel with sodium or potassium bichromate which helps in reducing heave.

Waterproofers : Alkyl chlorosilanes, siliconates, amines and quaternary ammonium salts are widely used. They do not increase the strength of soil but help to retain the natural strength in presence of water.

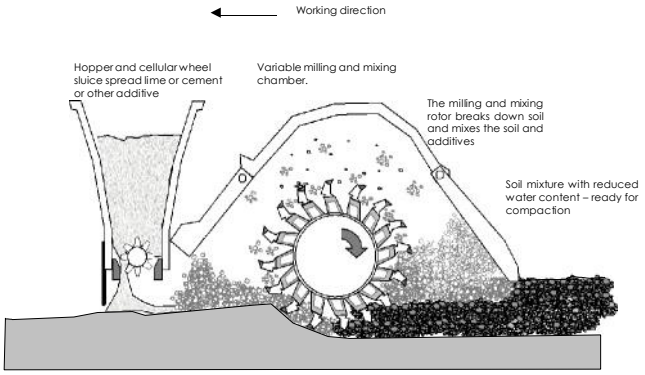
Polymers : Long chained molecules which react with the soil in stabilizing the soil. Natural polymers like resins, stabinol, shellac and synthetic polymers like PVA, aniline-furfural, Polyvinyl acetate are commonly used.

Aggregants & Dispersants : Help in altering the electrical forces between soil particles which affects the plasticity, permeability and strength of soil.

Soil Modification, Stabilisation and Recycling Machine



Schematic of Soil Modification and Mixing Chamber



THERMAL STABILIZATION

Heating or cooling soil can cause marked changes in its properties.

It is a very effective technique but expensive.

Heating Technique

As soil is heated, electric repulsion decreases and strength of soil increases.

With further increase in temperature, fusion and vitrification occurs where artificial aggregates are obtained which helps in mechanical stabilization.

Heat can be applied to soil by two ways:

- Burning of liquid or gas in boreholes
- Injection of hot air

It can be favourably used only when a site is located near a large and inexpensive heat source.

Heating Technique

Higher the heat input per mass of soil being treated, greater will be the effect.

Fine grained soils can be effectively stabilized by heating.

The effect of temperature and the possible changes in soil are:

TEMPERATURE	CHANGES IN SOIL PROPERTIES
100°C	Increase in strength of clay with decrease in compressibility.
500°C	Permanent changes in structure of clay resulting in decrease in plasticity.
1000°C	Causes fusion of clay particles.

Ground Freezing

Reduction of heat (cooling) in clayey soil increases interparticle repulsion resulting in a small loss in strength.

Freezing of pore water in soil is the most effective method of thermal stabilization.

Used in a wide range of soil types.

A refrigerant is brought in proximity of soil pore water which freezes the soil and a continuous wall is formed.

Freezing may be:

- Direct, by circulation of the primary refrigerant fluid like liquid carbon dioxide or liquid propane through the ground tubes.
- Direct, by injection of a coolant into the ground, such as liquid nitrogen.
- Indirect, by circulation of a secondary coolant through tubes driven into the ground.

ELECTRICAL STABILIZATION

Electrical stabilization is done by electro osmosis and effective in clayey soils.

As direct current is passed, pore water migrates due to the attraction of ions.

The strength of the soil is considerably increased due to removal of water.

It is an expensive method and used for drainage of cohesive soils.

GROUTING

GROUTING

It is a process of attained by injecting fluid like material into the subsoil ground improvement .

Generally done through boreholes and under pressure.

The main objective is to produce a stronger, denser and less permeable strata.

Applications:

Sealing pockets of unstable soil and rocks

To form grout curtains in layers of permeable strata below dams.

Sealing the base of structures founded on pervious strata.

Fixing the tendons in prestressed post tensioned concrete

TYPES OF GROUT

Cement

Cement and Sand

Clay-Cement mixture

Slag-cement

Resin gypsum-cement mixture

Clays

Asphalt

Pulverized fuel ash

Colloidal low viscous chemicals

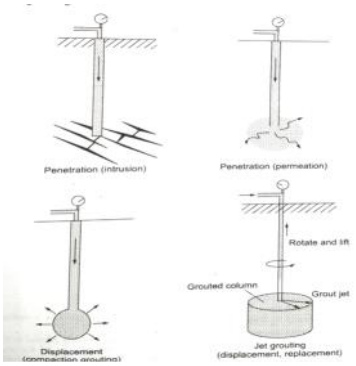
Basic categories of Grouting

Intrusion grouting

Compaction grouting

Permeation grouting

Jet grouting



Grouting Method	Description
Intrusion grouting	•Joints and fractures are filled by injecting grout. •Cement grout is generally used. •Used for foundation of water retaining structures.
Compaction grouting	•Called as displacement grouting. •A thin grout is injected under high pressure to form a series of intrusions. •Effective for loose cohesion less soils.
Permeation grouting	•A thin grout is injected into the soil so that it permeates into the voids. •Chemical grouts are effective than cement grouts. •Commonly used before excavations and tunnelling operations.
Jet grouting	•A special pipe is fitted with horizontal jets. •The jet injects the grout at high pressure. •A column of treated soil is formed around the pipe.

Grouting Materials

GROUT can be defined as a solution, an emulsion or suspension in water, which will harden after a certain time interval. It can be divided into two main groups:

a. Suspension Grout

b. Liquid Grout or Solution Grout.

Suspension grout is a mixture of one or several inert materials like cement, clays etc. suspended in a fluid (water). They are also referred as particulate grouts.

Liquid grout or solution grout consists of chemical products in a solution or an emulsion form and their reagents. The most frequently used products are sodium silicate and certain resins.

Suspension Grouts

Grouting with Soil

Fine sands, silts and clays can be used to fill the voids of coarse grained soils.

Clay is a complex compound which is used in medium sands with permeability of the order of 1 x 10-1mm/s.

They form gels when undisturbed and exhibit low shear strength thereby reducing permeability.

Bentonite clay is a commonly used soil grout material.

Widely used for underpinning shallow foundations

Suspension Grouts

Grouting with Cement

Ordinary Portland Cement is used

Water-Cement ratio ranging from 0.5:1 to 5:1 may be used

Admixtures/Additives can be added to this mixture to allow maximum physico-chemical reaction resulting in good strength.

Admixures include-clay, fine sand, flyash, fluidizers, accelerators and retarders.

Suspension Grouts - Contd...

Admixture	*Chemical*	*Optimum dosage, % cement weight*	*Remark*
Accelerator	Calcium chloride	1 to 2	Accelerates set and hardeni
	Sodium silicate	0.5 to 3	Accelerates set
	Sodium aluminate	0.5 to 3	Accelerates set
Retarder	Calcium lignosulphonate	0.2 to 0.5	Also increases fluidity
	Tartaric acid	0.1 to 0.5	
	Sugar	0.1 to 0.5	
Fluidiser	Calcium lignosulphonate	0.2 to 0.3	
	Detergent	0.05	Entrains air
Air entrainer	Vinsol resin	0.1 to 0.2	Up to 10% of air entraine
Expander	Aluminum power	0.005 to 0.02	Up to 15% preset expansi
	Saturated brine	30 to 60	Up to 1% postset expansi
Antibleed	Cellulose ether	0.2 to 03 (for w < 0.7)	Equivalent to 0.5% of mixi water

Suspension Grouts - Contd...

Applications:

- Fissured rocks
- Seepage cut-off beneath dam
- To control ground water movement

Solution Grouts

Silicate derivatives

Lignosulphite derivatives

Acrylamides

Phenoplasts

Grouts	*Corrosivity or Toxicity*	*Viscosity*	*Strength*
Silicates			
Joosten process	Low	High	High
Siroc	Medium	Medium	Medium high
Silicate-bicarbonate	Low	Medium	Low
Lignosulfates			
Terra Firma	High	Medium	Low
Blox-all	High	Medium	Low
Phenoplasts			
Terranier	Medium	Medium	Low
Geoseal	Medium	Medium	Low
Aminoplasts			
Hercules	Medium	Medium	High
Cyanaloc	Medium	Medium	High
Acrylamides			
AV-100	High	Low	Low
Rocagel BT	High	Low	Low
Nitto-SS	High	Low	Low
Polyacrylamide			
Injectite 80	Low	High	Low
Acrylate			
AC-400	Low	Low	Low
Polyurethane			
CR—250	High	High	High
CR—260			

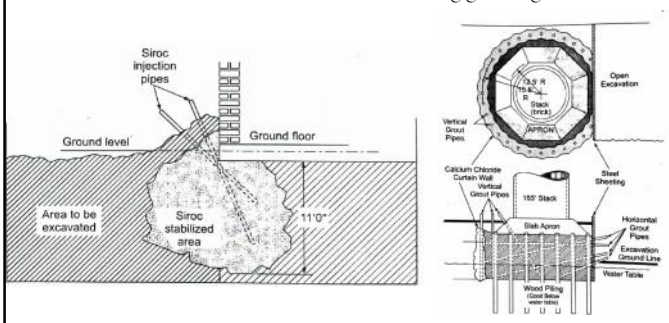
Solution Grouts - Contd...

Commonly used chemicals

- Sodium silicate
- Aluminium Sulphate
- Calcium chloride
- Sodium bicarbonate
- Sodium aluminates
- Phenol
- Resorcinol Formaldehyde
- Ethyl Acetate

Case studies of Grouting

Case Studies of Stabilization of sand using grouting.



GROUT INJECTION METHODS

Four main injection methods to inject grout into the ground are:

Drill Hole Method

A hole is drilled in the ground and grout is pumped via the grouting line into the surrounding ground with the use of single or double packers.

Drill Tool Method

It is a one-stage grouting method by means of the drill casings or rods.

Permeable soils are injected using rotary drilling.

During the drilling of the grout hole, a pre-determined distance is to be reached, drill rod is withdrawn and then grout is injected through the drill rod.

GROUT INJECTION METHODS

Grout Pipe Method

Grout pipes are installed in drilled holes for gout injection operation.

The gap between the grout pipe and the drilled hole is sealed.

For multiple-stage grouting, the sealed-in sleeve pipe injection method (the tube-à-manchetts method) is used. It allows several successive injections in the same zone.

The method is to place a grout pipe with rubber sleeves into a grout hole, which is kept open by casing or by mud.

This pipe is then permanently sealed in with a sleeve grout composed of grout.

GROUT INJECTION METHODS

Jetting Method

This method consists of lowering a drill pipe into a borehole which conveys pumped water, compressed air and grout fluid.

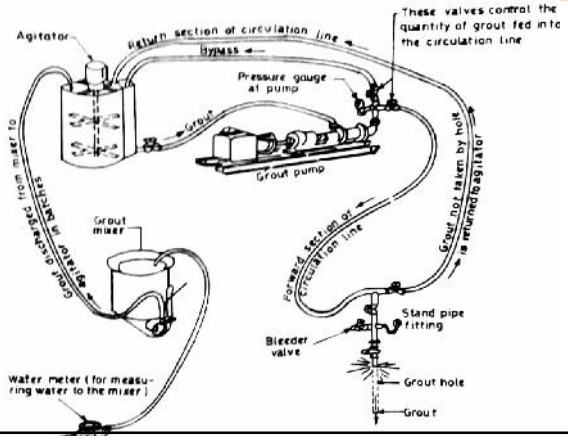
At the bottom end of the pipe, two nozzles are provided at 500mm apart.

The upper nozzle delivers water at 400 bar pressure and grout is delivered through the lower nozzle at 40 bar.

The drill pipe is raised by rotation and by simultaneous injection of grout.

By this technique, a column of replaced earth is formed.

LAYOUT OF GROUTING PLANT



GROUTING PLANT EQUIPMENT

Suspension and solution grouts use the same mixing plant and delivery system.

Grouting plant includes

Mixer, agitator, pump and pipe connected to grout holes.

Two piping systems are used for grouting

Single line type and Circulating type

The basic items required for grouting plant are:

Measuring tank : to control volume of grout injected

Mixer : to mix grout ingredients

Agitator : to keep particles in suspension until pumped

Pump : to draw the grout from agitator to pumping line

Control fittings : to control injection rate and pressure

GROUT MONITORING

Grouting activity	Monitoring
Prior to grouting	•Inspect equipment •Set elevation survey points •Establish monitoring plan and procedures
During drilling	•Conduct pre grout radar •Cross hole acoustic surveys
Grout Materials	•Certificate of compliance •Trial grout mixes
During grout	•Monitor injection pressure and flow rate •Plot grout-take log •Heave measurements on survey points
After grouting	•Final heave survey •Final review and signoff

Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings

Ravikumar C M[1,*], Babu Narayan K S[1], Sujith B V[2], Venkat Reddy D[1]

[1]Department of Civil Engineering, National Institute of Technology, Surathkal, 575025, India

[2]Department of Studies in Civil Engineering, U.B.D.T College of Engineering, Davangere, 577004, India cmravibdt@gmail.com, sujithbv@gmail.com

Abstract

Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subject to devastating earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. The present paper made an attempt to study two kinds of irregularities in the building models namely plan irregularity with geometric and diaphragm discontinuity and vertical irregularity with setback and sloping ground. These irregularities are created as per clause 7.1 of IS 1893 (part1)2002 code. In Oder to identify the most vulnerable building among the models considered, the various analytical approaches are performed to identify the seismic demands in both linear and nonlinear way. It is also examined the effect of three different lateral load patterns on the performance of various irregular buildings in pushover analysis. This study creates awareness about seismic vulnerability concept on practicing engineers.

Keywords Seismic, Irregularities, Pushover, Non-linear

1. Introduction

Earthquakes are the most unpredictable and devastating of all natural disasters, which are very difficult to save over engineering properties and life, against it. Hence in order to overcome these issues we need to identify the seismic per- formance of the built environment through the development of various analytical procedures, which ensure the structures to withstand during frequent minor earthquakes and produce enough caution whenever subjected to major earthquake events. So that can save as many lives as possible. There are several guidelines all over the world which has been re- peatedly updating on this topic. The analysis procedure quantifying the earthquake forces and its demand depending on the importance and cost, the method of analysing the structure varies from linear to non linear. The behaviour of a building during an earthquake depends on several factors, stiffness, adequate lateral strength, ductility, simple and regular configurations. The buildings with regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage compared to ir- regular configurations. But nowadays need and demand of the latest generation and growing population has made the architects or engineers inevitable towards planning of irregular configurations. Hence earthquake engineering has developed the key issues in understanding the role of building configurations.

1.1. Objective of the Study

To obtain the Seismic performances of different irregular buildings located in severe earthquake zone

(V) of India, and also identify the most vulnerable building among them.

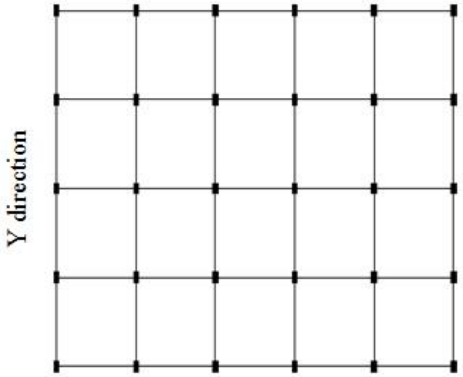
1.2. Scope of the Study

The Present work is focused on the study of Seismic de- mands of different irregular R.C buildings using various analytical techniques for the seismic zone V (hard rock) of India. The configuration involves plan irregularities such as diaphragm discontinuity, re-entrant corners and vertical irregularities such as geometrical irregularity, buildings resting on sloping ground. The performance was studied in terms of time period, base shear, lateral displacements, sto- rey drifts and eccentricity in linear analysis using a code – IS1893 (Part 1):2002 .Whereas the performance point and hinge status in Non linear analysis using ATC40. Also an attempt was made in pushover analysis to identify the correct lateral load pattern when different irregular buildings were considered. The entire modelling, analysis and design was carried out by using ETABS 6.0 nonlinear version software.

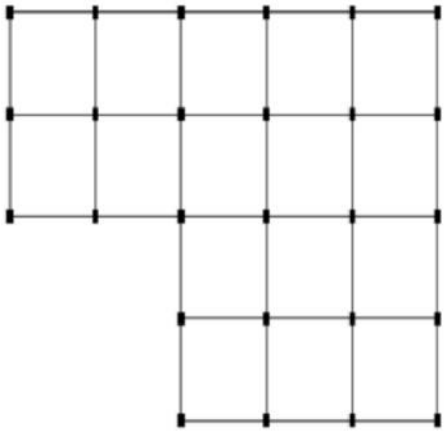
2. Illustrative Examples

The Layout of plan having 5X4 bays of equal length of 5m Figure 1. The buildings considered are Reinforced concrete

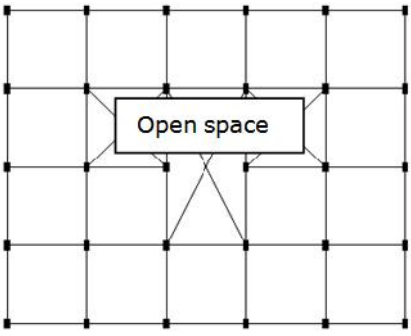
ordinary moment resisting frame building of three storeys with different irregular configurations. Here stiffness of the infill is neglected in order to account the nonlinear behaviour of seismic demands. The storey height is kept uniform of 3m for all kind of building models which are as below,



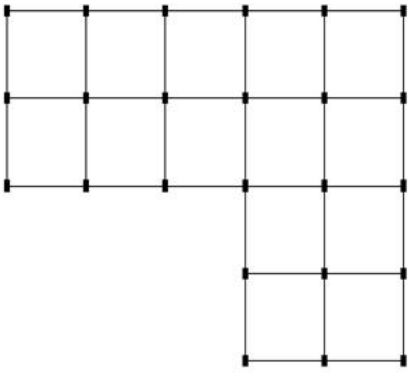
Model - 1



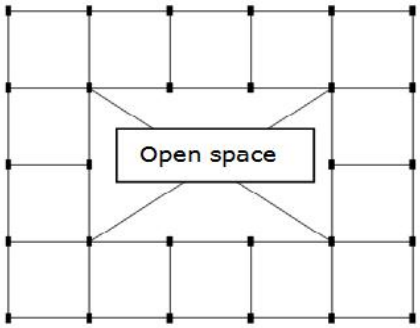
Model - L1



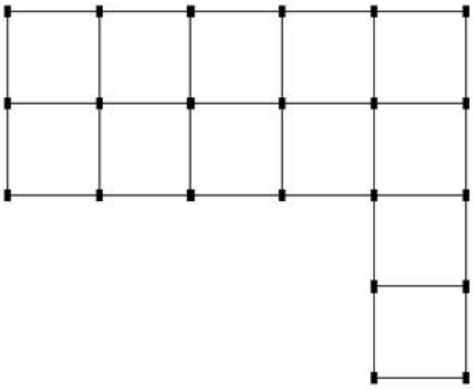
Model – D1



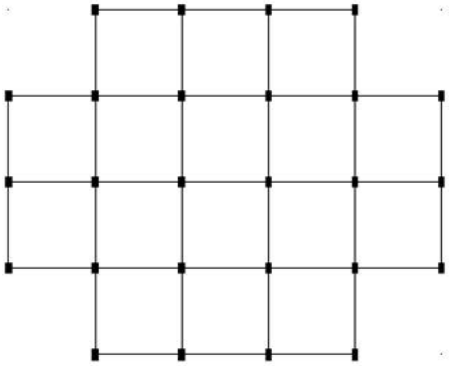
Model – L2



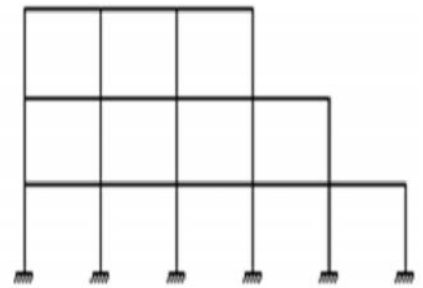
Model – D2



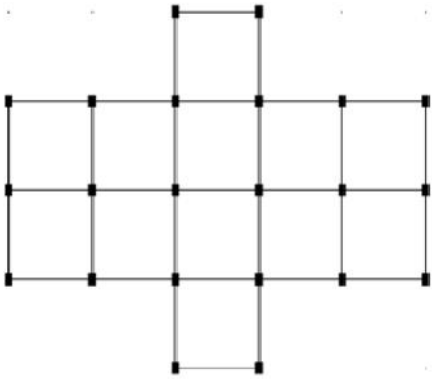
Model – L3



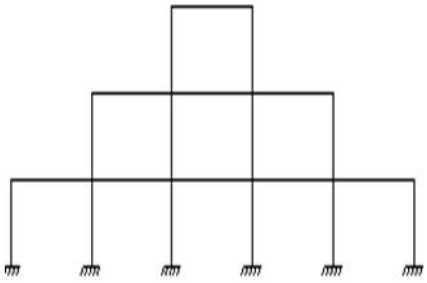
Model - P1



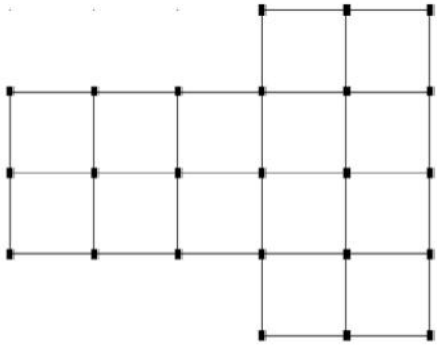
Model – V1



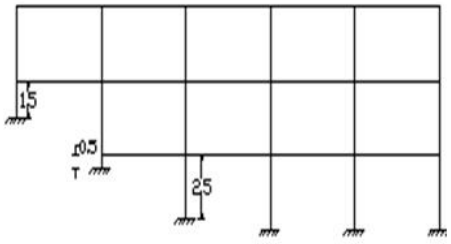
Model – P2



Model – V2



Model – T1



Model – V5

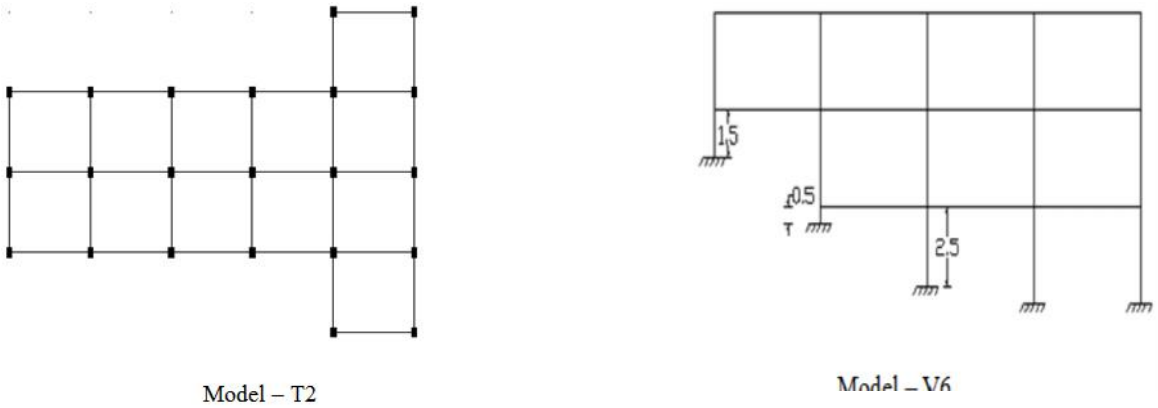


Figure 1. Building Models

(i)The Plan configuration consists of

Model 1 – Building in rectangular shape Model D1 – Diaphragm discontinuity, which is in T shape.

Model D2 – Diaphragm discontinuity, which is in rectangular shape.

Model L1, L2, L3 – Re-entrant corners in L Shape. Both projections provided are 40% 60%, 80% in X direction and 50% in Y-direction.

Model P1 and P2 – Re-entrant corners, in plus (+) Shape. Both projections provided are 20% of the plan dimension in their respective directions and 40% of the plan dimension in X direction, 25% in Y-direction.

Model T1 and T2 – Re-entrant corners in T-Shape. Both projections provided are 60% and 80% of the plan dimension in X direction and 25% in Y-direction.

(ii) a). The Vertical configuration of a structure and lateral force resisting system in

Model V1 – top story consists of an offset of 40% in X direction only on one side.

Model V2 – top story consists of an offset of 20% in X direction on both sides.

Model V3 – top story consists an offset of 40% in X direction on both sides.

Model V4 – adjacent story consists of an offset of 10.4% in X direction on both sides.

(ii) b). The Vertical configuration of a structure and lateral force resisting system is Model V5 – Resting on a sloped ground in X direction. Model V6 – Resting on a sloped ground in Y direction.

3. Analysis Methods

Analysis methods are broadly classified as linear static, linear dynamic, nonlinear static and nonlinear dynamic methods. In these the first two methods are suitable when the structural loads are small and no point, the load will reach to collapse load and are differs in obtaining the level of forces and their distribution along the height of the structure. Whereas the non-linear static and non-linear dynamic analysis are the improved methods over linear approach.

3.1. Equivalent Static Method

Equivalent static method of analysis is a linear static procedure, in which the response of building is assumed as linearly elastic manner. The analysis is carried out as per IS1893-2002 (Part 1) [6]

3.2. Response Spectrum Method

Linear dynamic analysis of the building models is per- formed using ETABS. The lateral loads generated by ETABS correspond to the seismic zone V and 5% damped response spectrum given in IS 1893-2002 (Part 1) [6]. The fundamental natural period values are calculated by ETABS, by solving the eigenvalue problem of the model. Thus, the total earthquake load generated and its distribution along the height corresponds to the mass and stiffness distribution as modelled by ETABS.

3.3 Pushover Analysis

Pushover analysis is one of the methods available to un- derstand the behaviour of structures subjected to earthquake forces. As the name implies, it is the process of pushing horizontally with a prescribed loading pattern incrementally until the structure reaches a limit state [ATC-40 1996][3].The static approximation consists of applying a vertical distribution of lateral loads to a model which captures the material non - linearity of an existing or previously designed structure, and monotonically increasing those loads until the peak response of the structure is ob- tained on a base shear versus roof displacement plot.

Here three static pushover cases are considered. In the first case gravity load is applied to the structure, in the second case lateral load is applied to the structure along X-direction and in the third case lateral load is applied to the structure along Y-direction for the three types of loading patterns

a).Code type - The force distribution is taken as per IS1893-2002(Part1) ELF (Equivalent Lateral Force) me- thod of vertical distribution.

$$F_j = m_j \; h_j k \qquad (1)$$

Where "m" is the mass, "h" is the height and "F" is the lateral force at j^{th} floor, k is 2.

b).Uniform - The force distribution is uniform only if all the floor masses are equal

$$F_j = m_j \qquad (2)$$

"m" is the mass and "F" is the lateral force at j^{th} floor.

c).1st mode – The force distribution is permitted when morethan 75% of the total mass participates in the floor.

$$F_j = m_j \qquad (3)$$

Where "m" is the mass, "$Øj1$" is the fundamental mode shape component at the j^{th} floor.

The buildings are pushed to a displacement of 4% of height of the building to reach collapse point as per ATC 40 (Applied Technology Council). Tabulate the nonlinear re- sults in order to obtain the inelastic behaviour.

4. Results and Discussion

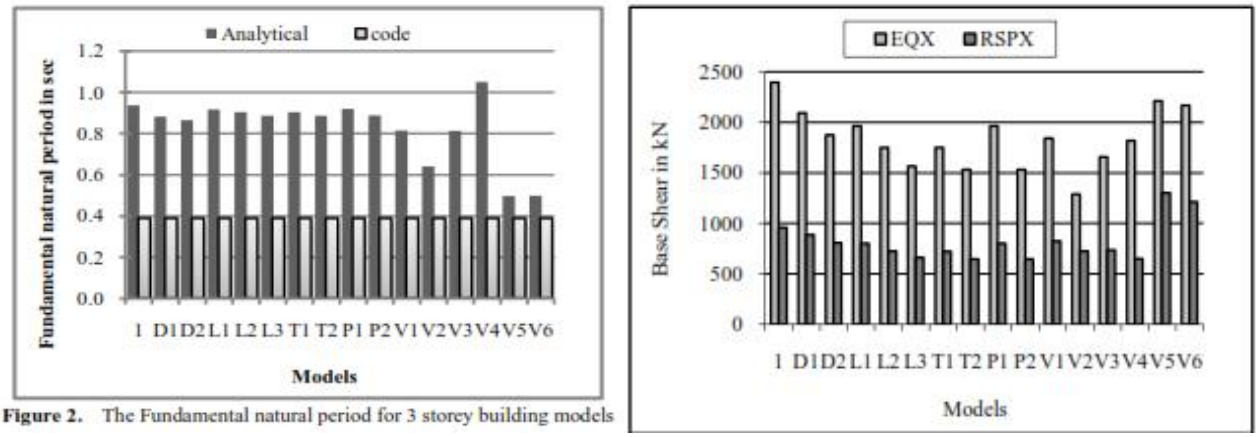


Figure 2. The Fundamental natural period for 3 storey building models

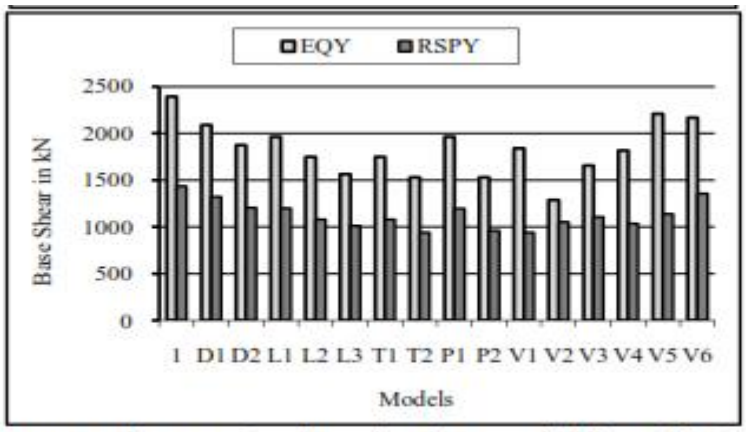


Figure 3. The Comparison of Base shear for 3 storey building models in X and Y direction

The comparison of natural period and base shear presented in the Figure 2 and Figure 3 shows that, the code IS 1893 (part-I) 2002 uses empirical formula to calculate natural period which is directly depends on the height of the building. Whereas the analytical procedure calculates the natural pe- riod on the basis of mass and stiffness of the building (Eigen value and Eigen vectors).Since, the code doesn't consider the irregular effects. The models D1, L2, L3, T1, T2, V1, V4, V5 and V6 subjected to displacements in both directions when the load was applied in particular direction. Which may results in twisting of building.

Here in all the three storied models the total number of hinges were varies from model to model that is mainly be beams and columns are getting reduced. The plan irregular models shows the displacement obtained are similar to model 1 for lower base shears in comparison to vertical irregular models. This shows that plan irregular models can deform largely for less amount of forces. Among all vertical irregular models the model V4 was more vulnerable.Hence they attract large force to deform moderately.

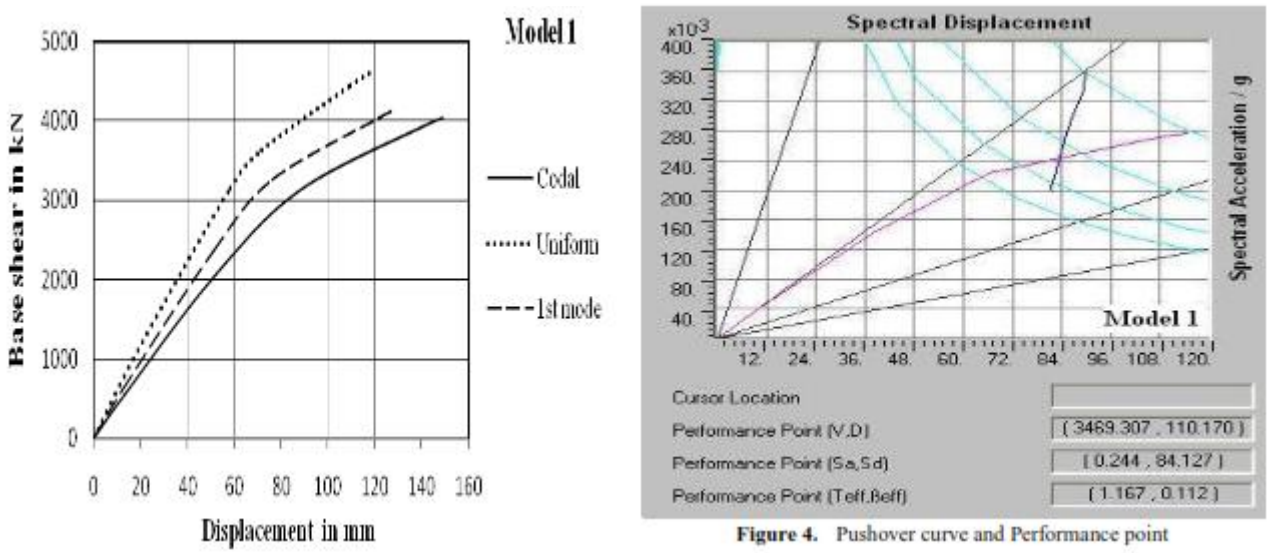


Figure 4. Pushover curve and Performance point

The diaphragm discontinued models D1 and D2 shows the performance levels at CP-C and LS-CP. This shows that there is a lack of transferring of forces to each vertical member due to irregular shape of opening. The re-entrant corner buildings (L1 to P2) decreases the performance point as the offsets increases. The vertical irregular models on plain ground (V1 to V3) shows the performance levels be- tween Life Safety (LS) and Collapse prevention (CP), but model V4 shows a large displacement for very less base shear and the performance level obtained in between col- lapse prevention and point C

(collapse). Whereas in sloping ground models the model V5 was found more vulnerable to earth quake. Since the performance goal was not achieved here. The model V6 achieves the performance after collapse point. Figure 4 shows pushover curve and performance point for model 1. Table 1 indicates performance point and its performance level for all 3 storey building models using codal type lateral load pattern.

5. Conclusions

1. The equivalent static method doesn't consider the irregular effects in the building and since it depends only on empirical formula the results obtained will be abnormal in comparison to response spectrum method.
2. The eccentricity between centre of mass and centre of rigidity varies even though in the absence of dual systems i.e. shear walls.
3. In pushover analysis the codal type of vertical distribu- tion of lateral force was found more detrimental in low rise models. Since more number of hinges are formed for a given displacement level compared to the other two patterns.
4. The performances of all the models except sloping ground (V5 and V6) are lies in between life safety and col- lapse prevention. This shows the buildings resting on sloping ground are more vulnerable to earthquake than rest of the models.
5. The result also shows that, capacity of the buildings may be significant but the seismic demand varies with respect to the configurations.

Table 1. Performance point and its performance level for 3 storey building models using Codal type lateral load pattern

Models	Displace	Base	Perform	Displa	Base	Perform
direction	X-			Y-		
Model - 1	110.	3469.3	LS-	82.	5200.5	LS-CP
Model -	104.	3279.8	CP-	80.	4732.3	LS-CP
Model -	103.	3012.7	LS-	78.	4264.4	LS-CP
Model -	108.	2921.5	LS-	82.	4310.6	LS-CP
Model -	106.	2691.5	LS-	81.	3870.8	LS-CP
Model -	105.	2488.4	LS-	71.	3842.5	LS-CP
Model -	107.	2655.3	LS-	81.	3883.3	LS-CP
Model -	105.	2419.8	LS-	73.	3274.0	LS-CP
Model -	107.	2914.3	LS-	81.	4332.4	LS-CP
Model -	106.	2377.6	LS-	79.	3429.5	LS-CP
Model -	105.	3191.8	LS-	94.	3953.1	LS-CP
Model -	100.	2870.7	LS-	73.	3729.2	LS-CP
Model -	105.	2815.8	LS-	75.	3777.2	LS-CP
Model -	115.	2310.2	CP-	79.	3684.1	LS-CP
Model -	-	-	Doesn't	83.	6019.2	D-

Model -	53.	4444.5	>	31.	5124.0	C-

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Mr. S. JAGADEESH KANNAN
Managing Director & Structural
Consultant Archetype Design Services
Pvt. Ltd. Coimbatore

SUSTAINABLE DEVELOPMENT IN STRUCTURAL ENGINEERING
PEB - PRE ENGINEERED STEEL BUILDINGS

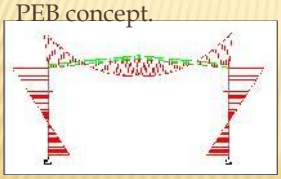
SUSTAINABLE DEVELOPMENT IN STRUCTURAL ENGINEERING
PEB - PRE ENGINEERED STEEL BUILDINGS

PRE ENGINEERED BUILDINGS

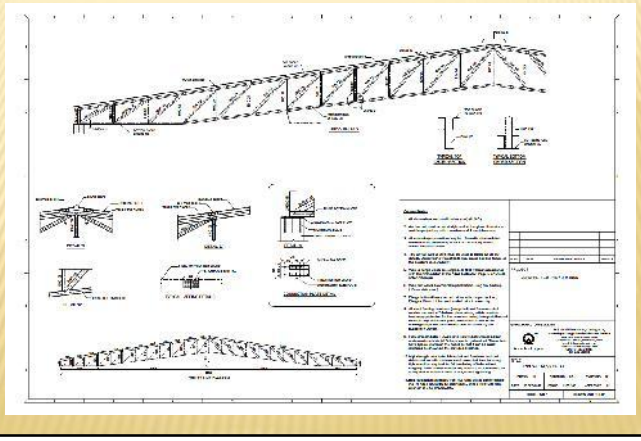
- Tailor made building based on client's requirement & actual design calculations using tapered sections.
- A combination of built up section, hot rolled section, cold formed elements and profiled sheets
- Designing and Fabrication is done in factory
- Building components are brought to site
- Then fixed/jointed at the site
- All connections are bolted.

BRIEF HISTORY

- Steel was very expensive, Then concept of PEB originate from here.
- The idea was that section should be provided as per B.M.D.
- This lead to the saving in steel and development of PEB concept.



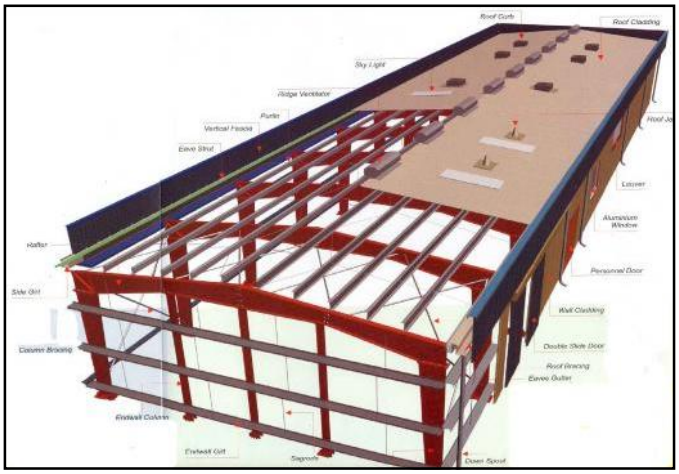
CONVENTIONAL TRUSS



TRUSS BUILDING

COMPONENTS

- Main Frame
  - Primary Members
    - Columns
    - Rafters
  - Secondary Members
    - Purlins
    - Girts
- Sheeting
  - Roof
  - Wall
  - Fascias etc
- Accessories
  - Ventilators
  - Sky Lights
  - Misc.



APPLICATIONS

- Industrial Buildings
- Warehouses
- Commercial Complexes
- Showrooms
- Offices
- Schools
- Indoor Stadiums
- Outdoor Stadiums with canopies
- Gas Stations
- Metro Stations, Bus Terminals, Parking Lots
- Primary Health Centers, Angan wadi's
- And many more…

Industrial

Parking lots

Indoor Stadiums

Railway Station

Aircraft

Metro Station

Wear house

High rise

OTHER MAJOR COMPONENTS OF

CRANE BRACKETS & BEAMS

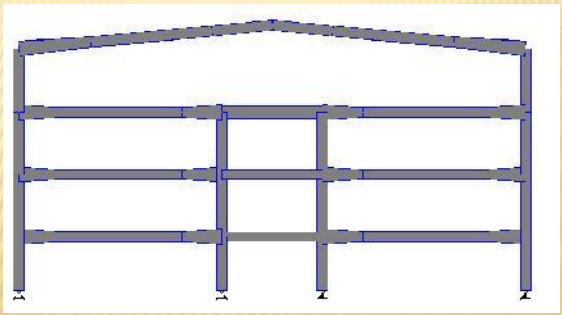
STRUCTURAL PARTIONS

MEZZANINE FLOORS

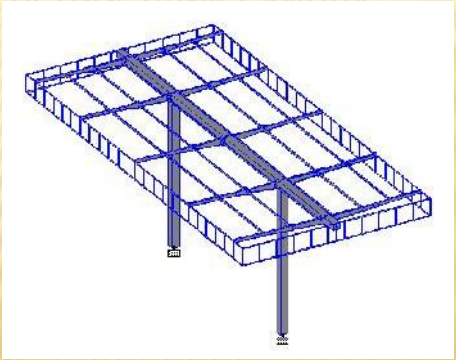
FASCIAS

CANOPIES

SOME OF OUR PROJECTS



PEB PETROL BUNK CANOPY



DESIGN CODES

- AISC – American codes
- MBMA – Metal Buildings Manufactures Association
- IS – Indian codes
- BS – British codes

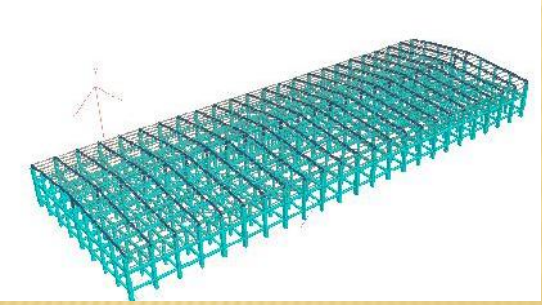
DESIGN

- DESIGN METHOD: Allowable stress design method is used as per the AISC specifications.
- DEFLECTIONS: Unless otherwise specified, the deflections will go to MBMA, AISC criteria and standard industry practices.
- PRIMARY FRAMING: Moment resisting frames with pinned or fixed bases.

DESIGN

- SECONDARY FRAMING: Cold formed Z sections or C sections for purlins or girts designed as continuous beams spanning over rafters and columns with laps.
- LONGITUDANAL STABILITY: Wind load on building end walls is transferred through roof purlins to braced bays and carried to the foundations through diagonal bracing.
- DESIGN SOFTWARE

  STAAD Pro
  MBS – Metal building software



ADVANTAGES

- Aesthetic Appeal
- Faster Completion
- Economical
- Seismic Resistance
- Ease of Expansion
- Maintenance Free
- Large Clear Spans
- Controlled Quality
- Hassle Free

- Self weight 30% lighter
- Primary Member is tapered section
- Secondary members are light weight rolled framed "Z" and "C" section

- Self weightMore heavy
- Primary memers are Hot rolled "I" section
- Secondary members are "I" or "C" section which are heavy in weight.

- Delivery – average 6 to 8 weeks
- Foundation-simple design, easy to construct & light wt.
- Erection cost and time-accurately known
- Erection process is easy, fast, step by step

- Delivery- average 20 to 26 weeks
- Foundation- expensive, heavy foundation required.
- Erection cost and time-20% more than PEB
- Erection process is slow and extensive field labor is required.

- Seismic Resistance-low weight flexible frames offer higher resistance to seismic forces
- Overall price - 30%lower
- architecture-achieved at low cast

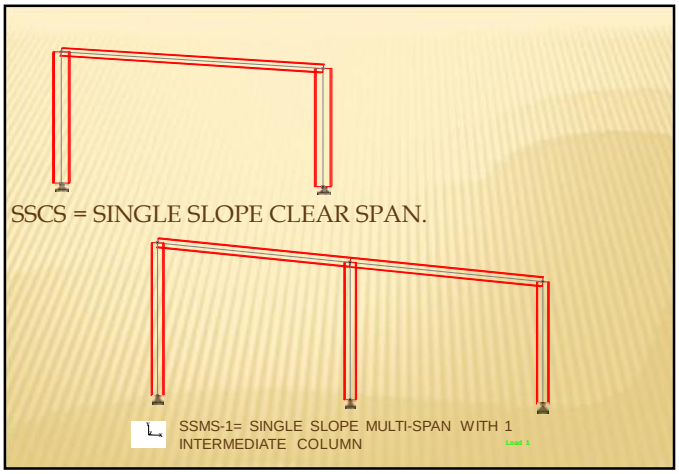
- Seismic Resistance-rigid heavy weight structures do not perform well in seismic zones
- Overall price - Higher Price per square meter.
- Architecture- achieved at higher cost

PEB FRAME WITH CRANE

PRE-ENGINEERED BUILDINGS NOMENCLATURE – STANDARD FRAMING SYSTEMS

RF = TAPERED COLUMN CLEAR SPAN

BC-1 = TAPERED COLUMN MULTI-SPAN WITH 1 INTERMEDIATE COLUMN.



ERECTION OF PEB

ERECTION SYSTEM

- **Preparation for Erection**

1. Pre Erection checks
2. Receiving Materials at site
3. Unloading Containers

- **Erection of the Framing**

1. Preparation of the First Bay
2. Main frames
3. Mezzanine floors
4. Crane Beams

ERECTION OF PEB FRAME

- PEB are often erected by specialized Builders with extensive experience in the erection of PEB'S

CONCLUSION

- PEB concept has been very successful and well established in North America, Australia and is presently expanding in U.K and European countries. PEB construction is 30 to 40% faster than masonary construction. PEB buildings provide good insulation effect and would be highly suitable for a tropical country like India.
- The pre-engineered building calls for very fast construction of buildings and with good aesthetic looks and quality construction. Pre-engineered Buildings can be used extensively for construction of industrial and residential buildings.

PARTICIPANTS PAPERS

CONTENTS

EXPERIMENTAL STUDIES ON MECHANICAL PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT FOR CEMENT & COARSE AGGREGATE BY GROUND GRANULATED BLAST FURNACE SLAG (GGBS) & CRUSHED GLASS

Mr. S. Yuvaraj* M. Gowthaman** M.K. Sai kartheka** R. Thivakar**M.Venkateshprasanth**

*Assistant professor, Email: yuvaraj.s@sece.ac.in

**UG student, Email: saikartheka.m.k@gmail.com

Sri Eshwar College of Engineering, Coimbatore, Tamilnadu, India.

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure leading to utilization of large quantity of natural resources. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive, this leading to usage of economically alternative materials in its production. Growing construction industry needs lot of construction materials, which leads to exploitation of natural resources. To reduce the exploitation, some alternatives have to be made in concrete to attain greater characteristics in strength. This paper aims to improve the properties of M30 grade concrete with partial replacement of cement by Ground Granulated Blast Furnace Slag, and coarse aggregate by Crushed glass in various proportions of 0%, 25%, 50%, 75%, 100%. For these various replacement percentages, a suitable proportion is selected for a particular grade of concrete to get optimum strength.For the study a total of 4 mixes were produced namelyM1, M2 (CG), M3 (GGBS) and M5 (Final mix).The cubes, cylinders and prisms are tested for compressive strength, split tensile strength, flexural strength to know the strength properties of different mixes at the age of 7 and 28 days respectively. Results indicated that mix M2 (CG) at 25% recorded the higher strength values than other mixes at the age of 7 days.

Key Words: Crushed glass, GGBS, Compressive strength, Tensile strength

STUDY ON IMPACT AND COMPRESSION STRENGTH OF CONCRETE BY USING BASALT FIBRE

P.Manibalan*, R.Baskar**

*Research Scholar, **Associate Professor

Department of Structural Engineering,

Annamalai University, Tamil Nadu, India.

Basalt fiber is relatively newcomer to fiber reinforced polymers (FRP) and structural composites. This study comparatively analyze the application of basalt as fiber reinforcement in

the investigation on the impact failure energy and compressive strength of M40 grade concrete. Basalt fiber were used in the concrete of various volume fractions such as 0.3%, 0.6%, 0.9% and 1%. The samples were tested under instrumented falling impact loading and compression testing machine compared with conventionally cured ones. It was observed from the test results that there was a significant effect of fiber inclusion on the compressive strength and impact strength of concrete. Compared with the plain concrete, the compressive and impact strength of concrete reinforced with 4 mm BF increased at 0.9% volume fraction. A good bond between the BF and the matrix interface is observed in the early age. However, this bond shows better result to a certain extent at 28 days.

Keywords: Fiber Reinforced Polymers (FRP), Basalt Fiber

AN INVESTIGATION ON ENEGRY EFFICENT CONCRETE USING PHASE CHANGING MATERIAL(PCM)

Mukundhan.M** Prasanth.S** Gopinath.S**

** Student

Climate change, caused by the release of greenhouse gases (mainly carbon dioxide) into the atmosphere, has been recognized as one of the greatest threats of the 21st century. Share of energy consumption in India and China has also been on the raise due to sharp urbanization, population explosion, and intensive growth of IT and related business. Buildings are the dominant energy consumers in modern cities account upto 40% energy consumption. Their consumption can be largely cut back through improving efficiency, which is an effective means to lessen greenhouse gas emissions and slow down depletion of non-renewable energy resources. There is over 50% saving potential in the building sector and thus it is considered as a potential sector to meet the challenges of global energy and climate change.. This technical paper discusses the role of energy efficiency in green buildings in Indian scenario to reduce the energy consumption and environmental degradation through Green House Gas emission (GHG). The possibility and benefits of harmonizing governmental and private-sector schemes are also discussed.

Our project paper presents a study has been undertaken for the newly constructed and existing buildings in order to assess its potential and capacity to save energy.

The paper thus deals with the various energy saving concepts which can be incorporated at the time of planning, designing, construction and execution stage to have energy efficiency in buildings keeping in mind the cost perspective.

Keywords: energy saving, green building,greenhouse gas

EXPERIMENTAL INVESTIGATION OF CONCRETE BLOCKS WITH PARTIAL REPLACEMENT OF CEMENT BY SILICA SAND

Senthil Naathan.B*,Gokul raj. P** Gopalakrishnan**Mahendran G**

* Assistant Professor, Email:vbsenthilnaathan@gmail.com

** (Student), E-mail:gokulgrp06@gmail.

Dr. N. G. P. Institute of Technology, Coimbatore,Tamil Nadu, India,

Concrete Block is one of the building material widely used in the construction of RCC structures. Cement is the main ingredient in a concrete block, which is the costliest ingredient.

A concrete block is one of several precast concrete products used in construction. The term precast refers to the fact that the blocks are formed and hardened before they are brought to the job site. Most concrete blocks have one or more hollow cavities, and their sides may be cast smooth or with a design.

Silica sand are very fine particles, which is a by-product from cement manufacture that can be used to increase the efficiency in concrete. silica sand has various advantages such as energy efficiency, fire resistance, reduction of dead load, low maintenance, low construction cost.

The present study is checking the compressive strength of concrete block with partial replacement of cement by Eco-sand. Replacement of cement by Eco-sand 0%,5% ,10% 15%,20% in concrete blocks.Some of the more important physical properties of eco-sand are: grain size and distribution, grain shape, sphericity, grain strength and refractoriness. In this project, we compare conventional blocks with concrete blocks by partial replacement of cement with silica sand.

The usage of silica sand may reduce the amount of cement in concrete blocks. Concrete blocks being usually larger in size than the normal clay building bricks and less mortar is required, faster of construction is achieved. Also building with concrete blocks provide facilities for concealing electrical conduit, water and sewer pipes wherever so desired and required less plastering.

Keywords: eco sand, by-product, waste material

EXPERIMENTAL STUDIES ON GEOPOLYMER CONCRETE UNDER AMBIENT CURING

C. Chinnaraj*, J. Balaji**, S. Gunasekaran**, D. Mahapandi**

*Assistant Professor, ** UG Student,

Department of Civil Engineering, Dr. N.G.P Institute of Technology, Coimbatore

During manufacturing of the Ordinary Portland Cement, enormous amount of Co_2 liberated. So use of alternative material instead of cement is necessary to avoid the pollution. Hence Geopolymer concrete was introduced, which is Co_2 emission free concrete where cement is replaced by eco-friendly material like fly ash, GGBS etc. In this experiment work, cement is 100 % replaced by Ground Granulated Blast furnace Slag (GGBS) which is collected from steel treatment plants. For fine aggregate, M-Sand was used, which is alternative to river sand. Alkaline solution is used instead of water which acts as binding activator. It contains sodium hydroxide and sodium silicate. Two different molarity of NaOHsolutions(12M, 14M) are prepared for alkaline solution to be added in concrete and their respective compressive strength and flexural strength are measured. Super plasticizer (sulphonated naphthalene) is used in mix to increase the workability of fresh concrete. Ambient curing is adopted for the casted concrete, which is known as normal room temperature. Different parameters of concrete i.e. concentration of sodium hydroxide, ratio of sodium silicate to sodium hydroxide, curing time, curing temperature, rest period and additional water content in the mix have been investigated.

Keywords: Geopolymer , GGBS, Alkaline Solution, NaOH, Sodium silicate.

BEHAVIOR OF SOFT STOREY BUILDING DURING EARTHQUAKE

S.Sridharan**Sanjay.A**Preetha.V**

** Students

The soft storey in high rise building plays an important role during seismic performances.Severe structural damage suffered by high rise buildings with soft storeyensures the capacity based design for better performance during earthquake.The first storey of the building is mainly used for parking. The RC framed buildings with the ground storey open are known to perform poorly during strong earthquake shaking, due to the absence of infill wall. The presence of masonry infill wall influences the overall behavior of the structure when subjected to lateral forces, when masonry infill are considered to interact with their surrounding frames the lateral stiffness and lateral load carrying capacity of structure largely increases. Earthquakes that occurred recently have shown that a large number of existing reinforced concrete buildings

especially soft storey building are vulnerable to damage or even collapse during a strong earthquake. The soft story in which the columns were unable to provide adequate shear resistance during the earthquake. So, in this paper the study is carried out with various building models involving the effect of soft storey.

Keywords:strong earthquake shaking, shear resistance

ORGANIC ARMOUR FOR STRUCTURES AND MONUMENTS AGAINST SULPHATE ATTACK DUE TO ACID RAIN

M.Yuvraj**, R.Vijay Krishna**

**UGStudents

The overview of our experiment is on the problem which is very real in the sub-continent. India enjoys the dubious distinction of releasing the maximum pollutants in the atmosphere after China. Total sulphur emissions are expected to rise from 4,400 kilo tonnes (kt) in 1990 to 6,500 kt in 2000, 10,900 kt in 2010 and 18,500 in 2020.When this dioxides of sulphur and nitrous reacts with water produces sulphuric and nitric acids. On account of this scientists have confirmed that rain in and around these cities is getting increasingly acidic in nature which is commonly known as 'The Acid rain'. During two decades, the acid content of rain in Delhi increased, which means its pH level decreased from 7.0 (1965) to 6.1 (1984), and in nearby Agra from 9.1 (1963) to 6.3 (1984). Acid rain has been held responsible for ruining the marble walls and pillars of one of the Seven Wonders of the World, TajMahal in India. Acid rain reacts with calcium to form calcium bicarbonate, which can be easily washed away. St. Paul's Cathedral in London and the Statue of Liberty in New York are known to be few victims of acid rain. Acid rain can damage buildings and bridges with metallic parts that are exposed to rain and fog. Not only does acid rain aggressively dissolve calcium in stone, but it corrodes certain types of metal. Vulnerable metals include bronze, copper, nickel, zinc and certain types of steel.

Apart from some derived remedies for the above discussed acid rain, we are stepped in the organic armour against sulphate attack, using Chlorinated Polyvinyl Chloride coating with some additives on the structures and monuments. Chlorinated polyvinyl chloride (CPVC) is a thermoplastic produced by chlorination of polyvinyl chloride (PVC) resin which is significantly more flexible and can withstand higher temperatures. CPVC having properties of acid resisting, low conductivity and excellent corrosion resistance at room temperatures. The extra chlorine in its structure also makes it more corrosion resistant. Whereas CPVC begins to soften at temperatures over 180°F. CPVC are available in market in the form of resins and solvent cement which is in

the state of powder and liquid respectively. Application of this CPVC in the counter layer of the specimen makes it as free from acid attack particularly sulphuric acid.

Keywords: sulphur emissions-sulphuric and nitric acids-The Acid rain-pH level decreased-organic armour-Chlorinated Polyvinyl Chloride-acid resistant-withstand higher temperatures-solvent cement-counter layer.

EXPERIMENTAL STUDY ON SELF COMPACTING CONCRETE USING GGBS

B.Angeljacquline**S.Sangeetha**M.Vinothini**

** UG Students

Self Compacting Concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in section with congested reinforcement. Use of SCC can also help in minimize hearing related damage on the work site that is induced by vibration of concrete. In this paper experimental studies are carried out for fresh and hardened properties of SCC in which cement is replaced by Ground Granulated Blast Furnace Slag (GGBS) in various proportions of concrete. The strength behaviours like Compressive behaviour and Flexural behaviour of SCC to be study. The parameters are tested at different ages in accordance with Bureau of Indian Standards (BIS) for the various proportions in which cement is replaced and also the obtained parameters are compared with normal SCC (100% cement). Super Plasticizer and viscosity modifying agent (VMA) is used to maintain workability and homogeneity with constant Water-Cement ratio.

Keywords: Self Compacting Concrete (SCC),Ground Granulated Blast Furnace Slag (GGBS), viscosity modifying agent (VMA)

EXPERIMENTAL RESEARCH ON BRICKS BY USING RICE HUSK, COW DUNG, EGG SHELL POWDER AS A PARTIAL REPLACEMENT OF FLY ASH

Anubala B**Backya P**, [3] Vivek S*

*Assistant Professor

** UG Students

Email id - vivek.sivakumar@srec.ac.in

Department of Civil Engineering, Sri Ramakrishna Engineering College, Coimbatore

Brick is a ceramic material used extensively in masonry construction. Brick is an important and prevalent building material that is used in a wide range of construction projects. India and the United States, for example, consume some 20 billion and 9 billion bricks each year, respectively. Various types of bricks are used in construction. The most common are conventional bricks. The other types of bricks are mostly “un burnt” building bricks used for temporary structures. Due to the exploitation of large amount of natural resources in the manufacturing of conventional bricks, we provided an alternative solution for the conventional bricks through this project. In our project, we have investigated the usage of wastes like rice husk, egg shell powder, cow dung as the partial replacement of fly ash in the manufacturing of eco-friendly construction bricks. The work is based on manufacturing of bricks and testing the compressive strength. We hereby identified that, this alterations have got reduced the consumption of natural resources, environmental pollution and the risks of waste disposal through our work. It is being concluded that the manufactured bricks have acquired the sufficient strength and it has been turned into a more economical rather than the other constructional materials.

Keywords: Bricks, Fly ash, Egg shell Powder, Cow Dung, Rice Husk, etc.

EXPERIMENTAL INVESTIGATION OF PARTIAL REPLACEMENT OF PAPER SLUDGE IN BUILDING BLOCKS

A.Anitha* C.Dyanesh**

* Assistant Professor, e-mail: anithavlb@gmail.com

** UG Student (Civil Engineering.), e-mail: cvldyan006@gmail.com

Department of Civil Engineering,

VelalarCollege of Engineering and Technology, Thindal, Erode-638 012.

This study examines the potential reuse of paper sludge in Building materials. The physico-chemical and engineering properties of a paper sludge sample from the TNPL have been

studied. The tests were conducted as per Bureau of Indian Standards (BIS) specification codes to evaluate the suitability of sludge for structural and non-structural applications by partial replacement up to 30% of cement. The cement–sludge samples failed to meet the required strength for structural applications. The strength and other properties met the Bureau of Indian Standards for non-structural materials such as Hollow, solid and pavement blocks. It is concluded that the substitution of paper sludge for cement, up to a maximum of 30%, may be possible in the manufacturing of non-structural building materials. Detailed leachability and economic feasibility studies need to be carried out as the next step of reuse.

Keywords:reuse of paper sludge, cement–sludge, Leachabilityand economic feasibility

REJUVENATION OF MANGROVE ECOTOURISM AT PICHAVARAM

Ar.K. Idhaya[*], R.B Parvatha[**] Dr.R.Baskar[***]

*Asst. Prof. School of Architecture and planning

**Final year student Arch. Dept. Periyar Maniammai University

***Associate Professor, AnnamalaiUniversity

Pichavaram is the of the unique Eco-tourism spots in South India. The backwaters, inter connected by the Vellar and Coleroon river systems. In Pichavaram, the mangrove forest is a coastal wetland ecosystem dominated by halophytic vegetantio second largest Mangrove forest in the world, near the temple town of Chidambaram, is one growing in brackish or saline waters. The Pichavaram mangroves attract an appreciable bird population of residents, local migrants and true migrants. At the mangroves, so far, 177 species of birds belonging to 15 orders and 41 families have been recorded. The main aim of the project is to develop pichavaram as an eco-tourist recreational space and also increase the economic standards of people through sustainability. This complex ecosystem is formed by the integration of a variety of plant and animal communities, living either as aquatic or terrestrial life. The survival of living organisms (Flora and Fauna) is directly influenced by physical and climatic factors that become the limiting factors for their growth. The forest also supports the human community that depends on the Flora and fauna for sustenance. This project focuses to instigate an ecologically sensitive and Green design through sustainability. Modification of the limiting factors would result in detrimental effects to the mangrove forest ecosystem. It can accommodate resort development with sustainable technology, when proper site planning and smallscale architecture are introduced into the ecosystem in Pichavaram. Proper site planning means the building layout should minimize the modification of the physical and climatic factors as well as sensitive to visitors needs and local people culture values. The architecture should be low-rise buildings inserted among the tree

stands and spread throughout the site rather than concentrated in small areas. All architecture should be raised on stilts and fully or partially ventilated so that visitors could experience and feel the real ambience of the mangrove forest setting.architecture, which serves to replenish the mangrove cover and to provide Low Environmental impact This project dealt with the present condition of Pichavaram and future development needed without affecting the natural ecological system. Rejuvenation of mangrove ecotourism at pichavaram is identified and focused towards sustainability. Considering the sensitivity of the pichavaram area many factors are included in this project.

Keywords:halophyticvegetantio, instigate an ecologically sensitive

ELECTROCHEMICAL TREATMENT OF REACTIVE BLACK-B DYE USING ALUMINUM ELECTRODES

Dr.R.Saraswathi* S.Manikandan**A.MohammedSiraj Ansari**

Electrochemical treatment was an effective technique in dye processing and it can be enforced to remove color from dye solution.An Experimental setup was made for electrochemical treatment of synthetically prepared Reactive Black B dye in batch mode operation using aluminum electrodes.Based on probability the operating parameters such as pH, Concentration, Electrolysis time, Retention time were determined from which the color removal efficiency (CRE) is optimized. The color removal efficiency of Reactive black B dye was achieved at 96.48% for the concentration of 10mg/l.

Keywords: Electrochemical treatment, dye processing, color removal efficiency (CRE)

REMOVAL OF HEAVY METALS Pb^{2+} & Ni^{2+} FROM AQUEOUS SOLUTION BY USING ACTIVATED CARBON

Shyam P S*, Manikandan C**& Senthil Rajan M**

*UG Students, E mailshyamkuttan87@gmail.com

**Assistant Professor, E mail senthilrajan@drngpit.ac.in

Department of Civil Engineering, Dr.N.G.P Institute of Technology, Coimbatore-48.

Metals are the most indispensible and highly essential elements continuously being used in the technological society around the globe, The technological advancements in mining and metallurgical industries during the 20^{th} century led to extraction of more than 40 metals from varieties of ores; and also, to effectively use or recycle them in the environment. Paradoxically the mushroomed growth of diversified industries utilizing several metals and their compounds in their

manufacturing processes is being posing potential threat to the biosphere; mostly through water pollution continuous efforts are also being implemented to combat this pollution problem throughout the World, using several physicochemical and biological and/or biochemical techniques. But, many of these techniques could only partially solve the pollution problem, just by moving the metals from one phase to other phase. Therefore, in order to tackle this problem, recovery and economical reuse of these metals in the respective industries is highly necessary. To achieve this, adsorption or sorption utilizing activated carbons (either commercial or prepared from biomaterials) and organic synthetic polymers are being adopted the adsorption capacity of activated carbon (XANTHIUMPENCYLVANICUM&CURCUMIN) towards metal ions such as Pb^{2+} & Ni^{2+} was studied . The adsorption capacity was performed by batch experiment as a function of process parameters (such as adsorption time and pH) experimental results showed that the removal percentage is increasing of metal ions at pH = 5.5, initial concentration of metal ions 12mg/L and after 90min of shaking was $Pb^{2+} < Ni^{2+}$

Keywords: Activated carbon (XANTHIUMPENCYLVANICUM & CURCUMIN) as an adsorption material

LANDSLIDE AND SLOPE STABILITY EVALUATION -A CASE STUDY IN COONOOR, TAMILNADU

Augustine Crispin C* P.D Arumairaj**, S.Janaki Raman**

Fast Urbanization and the morphological conditions of Coonoor, Tamilnadu have forced many people to settle on landslide prone slopes as evidenced by extensive landslide induced damages. The Coonoor area has been affected by landslides in the past and also the present. Due to this phenomenon many engineering objects such as buildings, roads are damaged and demolished. This has resulted in loss of lives also. The Landslide types found in the area are Earth slides, Debris Flow, as well as rock fall and rock rolling. Landslides in Coonoor are mainly due to rainfall, but human intervention of deforestation and plantation has turned this into a calamity. A slope failure is a phenomenon that a slope collapses abruptly due to weakened self retain ability of the earth under the influence of a rainfall or a earthquake. The fundamentals of slope stability evaluation encompass slope movements, methods for stability analysis, mechanics of slope failure and factor of safety. It involves laboratory and field methods to determine the shear strength of soil and remedial measures for correcting slides. This paper deals with Landslides and Slope stability evaluation of a particularly three slope areas in Coonoor, where the soil is to be tested in

laboratory and the failure of slopes and its stability is to be determined and analyzed by mechanical modules and electrical sensor systems and remedial measures will also be suggested.

Keywords:morphological conditions, landslides, Debris Flow

INFLUENCING EFFECT OF RANDOM INCLUSION SYNTHETIC FIBERS TO IMPROVE THE STRENGTH CHARACTERSTICS OF BLACK COTTON SOIL

S.Janaki Raman* LingalRishipal Reddy**

Email : janakiraman@karunya.edu

Karunya Institute of Technology and Sciences, Coimbatore.

The developing countries like India the most important requirement of any project after performance is economical feasibility and serviceability In this paper comparative study on strength characteristics of cohesive soil in different percentage of randomly inclusion of synthetic fibers. Investigation of the strength characteristics of black cotton soil with processed synthetic fiber(polypropylene, polyethylene) were mixed with the soil at three different ratio of 1%fibre, 2%fibre, and 3%fibre.Soil is compacted with standard proctors maximum density with low percentage of reinforcement, Atterberg's limit, CBR test and unconfined compression test were conducted on reinforced soil to investigate the strength characteristics of soil. black cotton soils are causing number of damages to the structures particularly light buildings and pavements compare to other natural hazards like earthquake, floods, etc. thus, worldwide these soils are considered to be problematic soils and pose several challenges for engineers Black cotton soil reinforced synthetic fiber is modified method developed in recent years because it is restraining the shrinkage tendency of soil. Use of synthetic fiber in civil engineering for improving soil properties is advantageous because they are cheap, locally available, bio degradable and eco friendly.

Keywords:strength characteristics of cohesive soil, Atterberg's limit, CBR test and unconfined compression test

WATER QUALITY EVALUATION IN TEXTILE INDUSTRIAL ZONE USING GIS

V.Priya* P.Bhuvaneshwari**, R.Keerthana**, S.Santhish Kumar**

*Assistant Professor

**UG Students

Department of Civil Engineering, Dr.N.G.P. Institute of Technology

The present study on water quality evaluation in textile industrial zone using GIS evaluates the extent of water contamination that happened in the textile industrial zone. Textile industries which contain chemicals and toxic substances eject their effluents first into the surface water. Surface water samples were collected near the industrial zone area around the Tiruppur zone. Various parametric analyses for calcium, hardness, pH, electrical conductivity, sulphate, nitrate, sodium, potassium, chloride, magnesium, total dissolved solids, bicarbonate, fluoride, etc were carried out. Results of parametric analyses were compared with BIS standards. The effluents from study area containing pollution indicating parameters considerably higher than the standards stipulated by BIS standards. Interpolate the map of water quality parameters using ArcGIS. Spatial variation of various surface water quality parameters were studied using GIS.

Keywords: Extent of Water Contamination, Containing Pollution, ArcGIS

RAINFALL SPATIAL ANALYSIS USING REMOTE SENSING DATA AND GIS

M.Arunkumar**S.Karthikeyan**P.Vivek** G. Krishnaraaju*

*Assistant Professor, krishnaraaju@drngpit.ac.in

**UG Student, Email id: arunvel710@gmail.com,

Department of Civil Engineering, Dr. N.G.P Institute of Technology, Coimbatore.

In this research paper, a study is made to understand the rainfall fluctuation with respect to spatial distribution for Tiruppur District. Rainfall is the one of the most important factor in hydrological cycle as well as climate elements. Amount of rainfall received over an area affects the availability of water resources and cropping pattern of an area. By analyzing the long term rainfall data, the results shows variation of rainfall for seasonal and monsoon period. The average mean rainfall of the study area will be considered for seven stations namely Kangeyam, Udumelpet, Tiruppur Town, Dharapuram, Avinashi, Palladam ,Mullanur. Among the climatic elements the rainfall is the first index, ever thought of by farmers and climatic analysers. The first section describes pre-processing, data collection, geo-referencing, digitization, database creation,

and refinement of data has been accomplished. Ground water is the major source in India not only for domestic use, but also for agriculture and industrial sector. Due to rapid increase in density of population, fast urbanization, industrialization and agricultural, use the demand of water is increasing day. The final integrated map shows three priority classes such as excellent, good and poor rainfall zones of the study area and provides a guideline for the suitability of agricultural activity.Remotely sensed data can provide useful information in understanding the distribution of rainfall, an important source of water supply throughout the world. In the present study, the modern geomatic technologies, namely remote sensing and GIS were used in the identification of rainfall potential zones in Tiruppur district of Tamil Nadu in India.

Keywords: Hydrological Cycle, fast urbanization, modern geomatic technologies

SUSTAINABLE DEVELOPMENT IN AGRICULTURAL SECTOR THROUGH ORGANIC FARMING

Swetha S**Vaishnavi** P Vivek S*

*Assistant Professor, Email id - vivek.sivakumar@srec.ac.in

**Student's

Department of Civil Engineering,Sri Ramakrishna Engineering College, Coimbatore

Humanity is facing possibly the greatest challenge in its history. Population is expected to reach 9 billion in 2030. At the same time agricultural land is becoming scarcer and poorer in quality. Furthermore, the environmental impact of intensive agriculture and the effects of climate change are threatening food security in many regions of the globe. Further, shortage of fossil fuels will have dramatic effects on the performance of intensive agriculture. There is an urge to develop more ecological agricultural practices both to meet the need to preserve agro ecosystems health and to deal with the reduced availability of cheap energy from fossil fuels. Organic agriculture along with other low input agriculture practices, results in less energy demand compared to intensive agriculture and could represent a means to improve energy savings and CO2 abatement if adopted on a large scale. At the same time it can provide a number of important environmental and social services, such as preserving and improving soil quality, increasing carbon sink, minimizing water use, preserving biodiversity, thereby guaranteeing healthy food to consumers. We claim that more work should be done in terms of research and investment to explore the potential of organic farming for reducing environmental impact of agricultural practices.

Keywords: Organic Culture, Co2 Reduction, Agricultural Practices, etc

OPTIMIZATION OF BEAM COLUMN JOINT FOR MAXIMUM SHEAR CAPACITY

JensiFebronia. S** Priya.J* Revathi. S**Hemalatha.G*
* Associate Professor
**UG student,
Karunya Institute of Technology and Sciences, Coimbatore- 641114

This paper presents analytical investigation carried out to optimize the shear capacity of beam column joints. Building designed as per IS456:2000 are deficient when subjected to lateral load. The detailing provided as per IS13920:2016 leads to congestion of reinforcement in beam column joints region. This leads to improper filling of concrete in the zone which leads to honey combing and reduction in strength. To address this issue, optimization of shear reinforcement in the joint region was done genetic algorithm. Optimization was done using tools of MATLAB. The reference frame taken for the design is the 4storey benchmark reinforced concrete building. The objective function was based on the maximum shear capacity calculated as the combine shear capacity of concrete and steel. The limit were fixed based on the designed criteria describe in the codes. From the analysis the optimized value were obtained for maximum shear capacity.

Keywords: Optimize the Shear Capacity, MATLAB, Combine Shear Capacity of Concrete

STUDY ON PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH WASTE GLASS IN CONCRETE

P.Prathiba**P.Nivedha**Kavitha.I**P.Manibalan*
*Assistant Professor
**UG student,
Department of Civil Engineering, Sri Manakula Vinayagar Engineering College, Puducherry

In construction materials, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. Waste glass is a major part of the solid waste. Glass is found in many forms like glass, bottles, sheet plate etc. These waste glasses are not easy to decompose they are creating many environmental problems. These waste glasses partially replace coarse aggregate in concrete in different percentage 5%, 10%, 20%, 30%. The compressive strength, split tensile strength, flexural strength of these concrete blocks is tested. This help to reduce the cost of the project.

Keywords:glass bottle, sheet plate, compressive strength, split tensile strength, flexural strength

A STUDY ON PROPERTIES OF GRAVEL WITH PARTIAL REPLACEMENT OF M-SAND RESIDUE

T.Ravindran**R.Gowri Shankar**R.Ganesh Kumar**

**UG Students

E mail: ravindaranthangavel@gmail.com

P.A. College of Engineering and Technology, Pollachi

This paper focuses on experimental study on Gravel with Partial Replacement of M-sand Residue in construction. The M-sand residue is finer and hence it cannot be disposed. An attempt has been made to find the suitability of the M-sand Residue when it is mixed with gravel. The experiments on Sieve Analysis, Specific Gravity, California Bearing Ratio, Direct Shear, Standard proctor, Permeability - Constant head method and Permeability - Falling head method have been carried out. The strength and properties of gravel have been studied and based on the result M-sand residue proportions is compared. For example 10% of M-sand residue is mixed with 90% of the gravel to find the strength and properties of the mixed proportion; likewise the same is repeated using the following proportion. Gravel: M-sand Residue – 80:20, 70:30 and 60:40.

Key words: M-Sand Residue, Gravel, Properties & Replacement

EXPERIMENTAL INVESTIGATION ON CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY ALCCOFINE (1203) AND FINE AGGREGATE BY RECYCLED PET FLAKES

T.Ravindran**R.Gowri Shankar**R.Ganesh Kumar**

** UG Students

E mail: ravindaranthangavel@gmail.com

P.A. College of Engineering and Technology, Pollachi

Construction industry needs some alternative materials due to depletion of natural resources. Our study is an attempt to use Polyethylene terephthalate (recycled plastic) as a partial replacement of fine aggregate and to find the optimum percentage of cement that is needed to be replaced by Alccofine 1203 which gives more strength with the addition of PET flakes. In this study recycled PET flakes replaces fine aggregate by 2% by the weight of fine aggregate and Alccofine 1203 replaces cement by 0%, 5%, 10% and 15% by the weight of cement in M30 concrete respectively. The compressive, split tension and flexural strength of concrete are tested

at 7^{th}, 14^{th} and 28^{th} days of curing. The results are compared with the results of conventional concrete.

Keywords: Polyethylene Terephthalate; Alccofine; Fine aggregate and cement

EXPERMENTAL STUDY ON SELF COMPACTING CONCRETE (SCC) USING ALCCOFINE

C.Prithiviraj* R.Sindhuja** D.Ramani** J.Sujitha**

* Assistant Professor

** UG Students, E mail:sindhuyuvi24@gmail.com

K.S.K College of Engineering and technology,Kumbakonam-612001.

This study aims to focus on the possibility of using ALCCOFINE as a mineral admixture in preparation of self compacting concrete (SCC). Alccofine is a newly generated micro fine material which has unique characteristics to enhance the strength and durability of concrete. This paper presents the result of an experimental study on self compacting concrete as partial replacement of cement. An attempt has been made to study the fresh and harden properties of concrete. For this work M20 grade concrete was used and test was conducted for various proportions of alccofine by various percentages (5%, 10% and 15%). The compressive strength was determined at 7 and 28 days. Super plasticizer (SP) and viscosity modifying agent (VMA) is used to maintain workability and homogeneity of concrete.

Keywords:ALCCOFINE, self compacting concrete (SCC), Super plasticizer (SP) and viscosity modifying agent (VMA).

STRENGTH PROPERTIES OF FIBRE REINFORCED CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY GRANITE DUST

K.S.Shobana* AjeethKumar.K**GokilaRamu**Sangavi.R**

*Assistant Professor,Email : shobacivil1992@gmail.com

** Students Email :sangavi.er@gmail.com

Department of Civil Engineering, Dr.N.G.P Institute of Technology, Coimbatore

Granite fines which are the by-product produced in granite factories while cutting huge granite rocks to the desired shapes. In this study, granite powder dust was used in concrete as a partial replacement of cement. Replacement of cement was made by level of 10%, 20% and 30% by weight of cement with adding 1% of glass fiber in concrete for M-20 mix proportion. Compressive strength, flexural strength and split tensile strength tests were conducted on all the

test specimens at 7-days, 14-days and 28-days curing time periods. Conventional concrete is also prepared and cured for same duration. Based on the compressive strength test, split tensile strength test and flexural strength test in the laboratory granite powder dust as replacement of cement with 1% of glass fiber is compared with the conventional concrete. The inclusion of granite powder dust & glass fiber in concrete have significantly improves its strength of concrete. The granite dust powder is free of cost. Hence it seems to be economical which can also be used to reduce the disposal of waste.

Keywords: Granite fines, glass fiber, Compressive strength, flexural strength and split tensile strength.

HYDRO GEO-CHEMICAL ANALYSIS FOR GROUNDWATER QUALITY USING GEOSPATIAL TECHNOLOGY

M.Ezhilarasi.M.E* Dr.V.Senthilkumar**

* Research Scholar, SSM College of Engineering, Komarapalayam

**Assistant Professor (Senior Grade),

Bannari Amman Institute of Technology, Sathyamangalam

Groundwater resources are explored in nature with the development of Irrigation activities, Industrialization and urbanization.But ground water is contaminateddue to human and industrial activities. Now a days this is a serious issueso the analysis of water quality is very important to preserve the natural eco system. The assessment of the ground water quality was carried out in the different wards of Coimbatore City. The present work is aimed at collecting the data with reference of top sheets for our studyarea. After that 55ground water samples are taken in two seasons. IN this sample the following chemical parameters have been considered Viz. pH, Totaldissolved solids, Electrical conductivity, Total alkalinity, Total hardness, Calcium, Magnesium. The obtained result of ground water samples of all the selected stations is to be analyze for a geochemical analysis. By using GIS the above chemical parameters are mapped in premonsoon and post monsoon seasons for the determined ground water potential. Thus the study of ground waterpotentialfor this sample suggest that the treatment of groundwater for the public utilization. Finally the location of treatment plant is to be identified with reference of supply and usage.

Keywords: Groundwater, chemical parameters,geochemical analysis, Water Treatment.

ASSESSMENT OF GROUNDWATER QUALITY IN TIRUPPUR TALUK USING GIS

V.Priya* M.Sugasini** R.Vergenia**R.Makizhan**

*Assistant Professor

** Students

Department of Civil Engineering, Dr.N.G.P. Institute of Technology

The study area on Tiruppurtaluk which is a growing Industrial area and the townships of Coimbatore.Tiruppur and Erode were surrounded by the Noyyal River, its canals, tanks, and rivulets. Mainly, Tiruppur area is facing plights due to the huge concentration of industrial wastes discharged by the cloth dyeing industries. Tiruppur area has surrounded by many numbers of dyeing and textile units in the upstream. These units are ejected their effluents into the river which contains lot of chemical and toxic substances. Based on the recent water quality analysis the irrigation wells along the river and in the downstream villages have been contaminated and the ecosystem hasbeen harmfully affected by the seepage and percolation of water stored in the Orathapalayam dam. Ultimately it also create problems to the ground water and surface water. Hence 15 samples of ground water are collected from the study areaand various parameteric analyses such aselectrical conductivity, calcium, magnesium, nitrates, pH, Hardness, Sodium, potassium, sulphate, fluoride, COD are determined. The effects of various pollutants present in the ground water is analysed.Finally the various parameters of the samples were interpolated using ArcGIS software.

Keywords: Dyeing and Textile, ecosystem, such aselectrical conductivity, calcium, magnesium, nitrates, pH, Hardness, Sodium, potassium, sulphate, fluoride.

MUNICIPAL SOLID WASTE MANAGEMENT USING GIS APPLICATION IN TIRUPPUR AREA

G.Krishnaraaju* Mitesh.J** GokulaKrishnan.K**Sahana.N**

*Assistant Professor, Email :krishnaraaju@gmail.com

**Students, Email :mmjnkfamily@Gmail.Com

Department of Civil Engineering, Dr.N.G.P Institute of Technology, Coimbatore

There is a tremendous amount of loss in terms of environmental degradation, health hazards and economic descened due to direct disposal of waste. It is better to segregate the waste at the initial generation stages rather than going for the later option which is inconvenient and expensive as well. There has to be an appropriate planning for proper waste management by

means of analysing the waste situation of the area. This project deals with, how the geographical information system can be used as a decision support tool for planning waste management. This is designed for the case study area in a tiruppur city for the purpose of planning waste management. Waste management issues are considered to solve some of the present situation problems like proper allocation and relocation of waste bins, check for unsuitability and proximity convenience due to waste bins to the users. Proposal of recyclable waste bins for the required areas and future suggestions in this project. The project has been implemented on the data prepared from the satellite images for the analysis. The results will suggest some modification in the existing system which is expected to reduce the waste management workload to a certain extent.

Keywords: Environmental Degradation, Geographical Information System,

A STUDY ON MECHANICAL PROPERTIES OF SELF DYNAMIC CONCRETE

R.SrinivasPrabhu* S.Muruganatham** S.Balasurya**

*Assistant Professor

**Students

Sri Eshwar College of Engineering, Coimbatore.

Self Dynamic Concrete (SDC) is defined as the highly workably concrete that can flow through dense reinforced or geometrically complex structural elements under its own weight to fill the voids without vibration. Making concrete structures without compaction has been done in the past. This leads to the development of self dynamic concrete (SDC).The workability properties of SDC such as filling ability, passing ability and segregation resistance are evaluated using workability tests. Present day self dynamic concrete can be classified as an advanced construction material, As the name suggests it does not require to be vibrated to achieve full compaction. This offers many benefits and advantages over conventional concrete. These includes an improved quality of concrete and reduction of on site repairs, faster construction times, lower overall costs, facilitation of introduction of automation into concrete construction. Adding the admixture of conplast SP430 in different ratios to achieve the self dynamic concrete. The optimum percentage was determined and the workability tests and mechanical properties was carried out for optimum percentage.

Keywords: Self Dynamic Concrete (SDC), Geometrically Complex Structural Elements.

WATER QUALITY INDICES IS THE SIGNIFICANT TOOLS FOR WATER QUALITY ASSESSMENT: A REVIEW

Vivek S* Yuvasri C**Dhivya R**

*Assistant Professor, Email id - vivek.sivakumar@srec.ac.in

**Students

Department of Civil Engineering, Sri Ramakrishna Engineering College, Coimbatore

Water quality is a significant criterion in matching water demand and supply. Securing adequate freshwater quality for both human and ecological needs is thus an important aspect of integrated environmental management and sustainable development. To represent water quality in a lucid way different water quality indices for water quality assessment are used which aim at giving a single value to the water quality of a source reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data. In this review, various water quality indices (WQI) used for assessing surface water quality are discussed. As different National and International Agencies involved in water quality assessment and pollution control defines water quality criteria for different uses of water considering different indicator parameters, so there are numerous WQI specific to any region or area. An attempt to cover different water quality indices developed worldwide, their background and application area has been discussed here.

Keywords: Water Quality, index, review, water parameters, quality scale

SUSTAINABLE GREEN CONSTRUCTION MATERIALS

Ms.M.Brindha*

*Assistant Professor, Email :brindha2187@gmail.com

Department of Civil Engineering,

Hindusthan College of Engineering and Technology, Coimbatore, India

The objective of this paper is to introduce the green buildings using sustainable construction material which minimize the demand on non-renewable resources, maximize the utilization efficiency of the renewable resources, when in use, and maximize the reuse, recycling, and utilization of renewable resources. It maximizes the use of efficient building materials and construction practices. This requires close co-operation of the design team, the architects, the engineers, and the client at all project stages. Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective

of green buildings is to reduce the overall impact of the built environment on human health and the natural environment by Efficiently using energy, water, and other resources; Reducing waste, pollution and environmental degradation. In the effective view green construction includes, increasing energy efficiency of a building using green natural or renewable resources instead of non-renewable resources.

Keywords: Sustainable, Green building, Efficiency.

EXPERIMENTAL STUDY ON THE EFFECT OF BASALT FIBRE ON MECHANICAL PROPERTIES OF CONCRETE CONTAINING METAL CASTING SAND

S. Deepika*Anjana Joseph** N. Hari Prakash** A. Nivitha**V. S. Vishak**

*Assistant professor, Email: deepikas@sece.ac.in

**UG students, Email: nivithaamuthan@yahoo.com

Department of Civil Engineering, Sri

Eshwar College of Engineering, Coimbatore, Tamil Nadu, India.

Researches on the Fibre Reinforced Concrete (FRC) in recent days have created curiosity in the benefits that the fibre offers. Concrete is weak intension and poor in resistance to cracking. To overcome these defects the fibre is reinforced in the concrete. Among the different types of fibres, basalt fibre is the most promising one that is used as fibre reinforcement material in this study. The basalt fibre used in this project is having a diameter of 13μm and a length of 12mm. The amount of basalt fibre addedis from 0% to 0.5% by the weight of cement. As a partial replacement of river sand is made with 30% of metal casting sand (ferrous) constantly to enhance the compressive strength of the concrete. M30 grade of concrete of cubes, cylinders and prisms are casted with and without basalt fibre. Mixdesigns are calculated as per the amount of basalt fibre added such as M1, M2, M3, M4, M5 andM6. Mechanical properties of concrete such as compressive, tensile and flexural strength are then tested after 7 and 28 days in order to find the effect of basalt fibre and metal casting sand aspartial replacement of cement and sand respectively. The results obtained proves that there was an increase in the strength of concrete upto M4 mixand later found a drop in the strength for further mixes. M4 mix containing 0.3% of basalt fibre yielded enormous strength than other mixes at both 7 and 28 days.

Keywords: Basalt fibre, fibre reinforced concrete, metal casting sand, partial replacement of river sand

GEOPOLYMER CONCRETE USING LOW CALCIUM FLY ASH UNDER AMBIENCE CURING

C.Chinnaraj*P.Gowtham Ajay** S.JanaYohaSruthi** K.Jeevitha**

*Assistant Professor

**UG Students

Department of Civil Engineering, Dr.N.G.P Institute of Technology, Coimbatore, India.

Concrete is the most widely used construction material. Its usage by the communities across the globe is second only to the water. Customarily, concrete is produced by using the Ordinary Portland Cement(OPC) as the binder. The usage of OPC is on the increase to meet infrastructure development. It is well known that cement production depletes significant amount of natural resources and releases large volume of carbon di oxide. Cement production is also high energy intensive, after steel and alumina. On the other hand, coal burning power generating plants produce huge quantities of Fly Ash. The volume of Fly Ash would increases as the demand for power increases. Most of the Fly Ash is considered as waste and dumped in landfills. But the Fly Ash can be used instead of OPC as a binder. The results show that low calcium Fly Ash under ambience curing by adding admixtures in it can also be adopted for the construction.

Keywords: Alkaline solution, Fly Ash, Geopolymer, GGBFS.

EXPERIMENTAL STUDY ON PCC WITH PARTIAL REPLACEMENT OF M-SAND BY ECOSAND

B. Senthil Naathan* MHarisbaskar** R Thavakkumar** P Suresh**

*Assistant professor, Email :vbsenthilnaathan@gmail.com

**Students, Email :baskarm47@gmail.com

Department of Civil Engineering,

DR.N.G.P institute of technology, Coimbatore District, Tamil Nadu, India.

All over the world, concrete construction activities are taking place on huge scale. Natural sand (river sand) is one of the key ingredients of concrete and it is becoming demand and expensive. Manufactured sand (M-sand) is a substitute of river sand for concrete construction which is produced from hard granite stone by crushing. Eco-sand is fine particles which is a by-product from cement manufacturing. Effective use of this waste material should be done for cost efficiency. The present study is about the compressive strength of concrete block with partial replacement of M-sand by Eco-sand. The conventional river sand is replaced with M sand and partial amount of silica sandReplacement of M-sand by Eco-sand at various

percentages 0%,6%,12% 18%,24%&30% in PCC.It is verified that the optimum replacement percentage of M-sand by Eco-sand and the properties of fresh concrete and hard concrete in PCC with eco-sand. The comparison of economic advantages of m sand and eco sand. The main objective of this project is to reduce the air pollution and eco-friendly. The various proportion is carried out and tested.

Keywords:eco sand , by-product , waste material.

EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OFCONCRETE BY BINARY AND TERNARY COMBINATION OF CLAY BRICKDUST, DOLOMITE & M-SAND WITH FINE AGGREGATE

S. Yuvaraj*T.Piragavi** Priyanka.S**T.Ragunath** T.R Ramesh**

*Assistant professor, Email: yuvaraj.s@sece.ac.in

**Students, Email: spriyankasenthil@gmail.com

Department of Civil Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamilnadu,

Natural river sand is the most widely used fine aggregate in concrete. Thedemand for natural sand in the construction industry has consequently increaseddue to its increase in price. The government has already banned sand mining due toenvironmental problems in some identified areas of major rivers.Thus, an investigation is needed to identify a suitable substitute that shouldbe eco-friendly and in order to fulfil the requirement of fine aggregates by analternative material like dolomite, M-sand and clay brick dust in right proportion can be used in concrete.In this experiment the natural river sand is replaced by binary and tertiarycombination of clay brick dust , dolomite and M-sand by various proportions of 0%,25%,50%,75%,100%. For these various replacement percentages, a suitableproportion is selected for a particular grade of concrete to get optimum strength. Forthe study a total of 5 mixes were produced namelyM1, M2(DP),M3(CBP),M4(M-Sand)and M5(Final mix).Under the macro study, Compressive strength , Split tensile strength andFlexural strength tests were conducted to know the strength properties of differentmixes at the age of 7 and 28 days respectively. Results indicated that mix M3(CBP)at 25% recorded the higher strength values than other mixes at the age of 7 days butwherein at 28 days mix M4(M-sand) has higher strength due to its increase in density.

Keywords: Dolomite, Clay brick powder, M-sand, 100% fine aggregate replacement.

STUDY ON PARTIAL REPLACEMENT OF RED SOIL USING GRANITE DUST IN BRICKS

K.S.Shobana* Jeganathan.T**Shanthini.B**Varshini.P**

*Assistant Professor,Email : shobacivil1992@gmail.com

**Student, Email :shansugi1997@gmail.com

Department of Civil Engineering, Dr.N.G.P Institute of Technology, Coimbatore

This paper investigates the possibility of utilizing granite waste in replacement of red soil in bricks, in order to reduce the disposal of waste. By this method, the usage of natural resources can be reduced and the manufacturing cost of bricks is also reduced by using the industrial waste materials. This paper shows how the granite powder can be incorporated into clay mixture without decreasing their mechanical properties. It is expected that the presence of granite waste in bricks allow better performance than that of conventional bricks. Granite industry produces a huge amount of waste during the process of cutting. The red soil and granite waste which are used for the preparation of bricks were collected from Kanuvai, Coimbatore. The clay was collected from Veerakeralam area, Coimbatore. Particle size test and specific gravity test were conducted for determining the physical properties of red soil and granite dust. Hence Granite waste is used in bricks because the physical properties of granite waste and red soil are nearly similar. Granite waste are used in the proportions of 5%, 10% and 15% for the preparation of bricks and the bricks which are prepared were subjected to the water absorption, efflorescence, warpage, dimension, compression and bond strength test. The results of all such tests were obtained and compared with the conventional bricks .

Keywords: Granite Waste, Efflorescence, Warpage, dimension, Compression and Bond Strength Test.

AN EXPERIMENTAL INVESTIGATION ON CONCRETE BY REPLACING FINE AGGREGATE WITH GGBS

A. Kannan** A. MydeenBasha** S. Tamil Vanan** G. Ramesh kumar*

*Assistant Professor, Email :grameshkumar1990@gmail.com

** Student, Email :kannanattghs@gmail.com

Department of Civil Engineering, Dr. N.G.P Institute of Technology, Coimbatore

Concrete place a virtual role in the development of infrastructure viz., building industrial structures and highway structures etc., leading to utilization of large quantity of concrete. Alternative are always a savior lock owing to the scarcity of availability of river sand switching

on to quarry stone dust is being critically observed arising from quarrying action, innovations delivered various smart materials that can be adopted readily for usage in concrete. Ground Granulated Blast furnace Slag ash (GGBS) is a byproduct from the blast furnaces used to make iron and steel. Current total productions of steel slag in India, is around 12 million tonnes per annum (Indian minerals yearbook, may 2016). This investigation is done to study the effect of replacement of quarry stone dust with GGBS. M25 grade of concrete with W/C 0.45 is used & the investigation is carried out with three different percentages of quarry stone dust replaced by GGBS i.e., 80%, 90%, and 100% with weight proportion of quarry stone dust. For all mixes hardened concrete test were conducted at the age of 7 & 28 days of curing.

Keywords: Quarry stone dust, Ground Granulated Blast furnace Slag, compressive, split tensile &Flexural strength.

INVESTIGATION OF CONCRETE BY REPLACEMENT OF FINE AGGREGATE WITH M-SAND AND FOUNDRY

Barathikannan T**Deepanchakkravarthi S** Karthikeyan S**Boobala Krishnan K V*

*Assistant Professor, Email: boobalakrishnan007@gmail.com

**Students, Email: deepanvijay1024@gmail.com

Dr. N.G.P. Institute of Technology, Coimbatore – 641 048,Tamilnadu, India.

Foundry sand (FS) is a by-product from the metal alloys casting industry with high silica content. Silica sand is bonded with clay or chemicals, and is used for the material casting process. Foundries recycle the sand many times, and when the sand is no longer recyclable, it is disposed of; this is called foundry sand. About 15% of sand used by foundries is ultimately disposed of, amounting to millions of tons. In India, many foundries dump this waste in nearby vacant areas which creates an environmental problem. With increased restrictions on disposal in nearby areas, industries are constrained to find alternative ways to reuse waste.

In this project foundry sand is partially replaced instead of fine aggregate in different proportions, namely 10%, 15% and 20% in M25 grade of concrete. The remaining of fine aggregate is replaced by M-sand. Concrete cubes, cylinders and prisms are casted and put for compressive, split tensile and flexure tests respectively.

Key words: Waste foundry sand, Concrete, compressive test, split tensile test and flexure test.

A STUDY ON PLANNING AND DESIGNING OF A SUSTAINABLE MULTI-MODAL TRANSIT HUB AT UKKADAM – COIMBATORE

Mrs.Prathibaa.K* DafneMartina.X** Monica.T**

*Assistant Professor, Email :prathibaa@karunya.edu

**UG Students, Email: dafne3martina97@gmail.com

Karunya Institute of Technology and Sciences, Coimbatore-641 114, Tamilnadu, India

According to the census, Coimbatore's population is set to grow to nearly 3.8 million by 2031. With increasing population, the city is witnessing rapid motorization, increased congestion, and pollution. Transport planners have increasingly come to a consensus that successful cities facilitate the movement of "people, not vehicles", a goal clearly expressed in the National Urban Transport Policy (NUTP 2006). The Government of Tamil Nadu (GOTN) and Coimbatore City Municipal Corporation (CCMC) have chosen to create a sustainable, robust, highcapacity mass rapid transport system. The appropriate solution for Coimbatore is a fullfeaturedBRT and metro system that pairs significant improvements in performance with other elements, such as a dedicated right-of-way for buses (BRT) that is segregated from general traffic. Most importantly, Ukkadamis taken as start point (as per ITDP), with majority of city buses originating from this point and passing through key corridors of the central business district (CBD). The allocation of multimodal transit hub (MMTH) provides the articulation between different modes of transport, in order to more rapidly and effectively transfer operations of inhabitants, materials and goods. This mass transport feasibility study aims to provide answers for Coimbatore's sustainable development—to provide a development strategy that meets the needs of present Coimbatore without compromising the ability of the city's future generations to meet their own needs.

Keynotes: Sustainability,Durability,Safety.

EXPERIMENTAL STUDY ON HYBRID FIBRE REINFORCED CONCRETE

HaripriyaRenukumar* Mohammed Zubair K** Reshma R**Sukrithi S*

*Assistant Professor, Email :sukrithi.rajan@gmail.com

**Student, Email :haripriyakaruthedathu@gmail.com

Department of Civil Engineering, Dr.N.G.P Institute of Technology, Coimbatore

Plain concrete possess very low tensile strength, limited ductility and little resistance to cracking. In order to meet the required strength, fibres are used in normal concrete. Adding fibres to the concrete greatly increases the toughness of the material. When two or more fibres are added

to concrete to make the composite structure gives maximum strength to concrete that type of concrete is known as Hybrid Fibre Reinforced Concrete(HFRC). This experiment aims to study the mechanical properties of hybrid fibre reinforced concrete where the fibres used such as steel fibre, glass fibre and polyester fibre. For this purpose, one normal control mix and three hybrid fibre reinforced concrete mixes were prepared. The volume of steel fibre is kept constant as 1%, the volume of glass fibre varied as 0.5%, 1%, 1.5% and the volume of polyester fibre varied as 0.1%, 0.2%, 0.3%. Slump test was carried out for each mix in the fresh state in order to determine the workability of the hybrid fibre reinforced concrete. Meanwhile compressive strength, flexural strength and split tensile test were carried out to study the mechanical properties of the hybrid fibre reinforced concrete and the results are compared with Conventional Concrete. The result of this study revealed that the fibres like steel fibre, glass fibre and polyester fibre used in 1%, 0.5%, & 0.1% percentage of total weight of the mix gives the better result when compared to others.

Keywords: Mechanical Properties, Steel Fibre, Glass Fibre, Polyester Fibre.

STABLIZATION OF SOIL BY USING PLASTIC WASTE MATERIALS

G Ramesh Kumar*SPremBalaji** L Rajesh** P Vetrivelan**

*Assistant professorEmail:grameshkumar1990@gmail.com

**Students, Email: sbpprembalaji@gmail.com

Department of Civil Engineering,

DR.N.G.P Institute of Technology, Coimbatore.

Soil is the key element of this nature and all the basic needs of life such as food house and cloths are fulfilled by the soil. Black Cotton Soil with high potential for swelling and shrinking as a result of change in moisture content are one of the major soil deposits of India. Soil Stabilization is the process which improves the physical properties of soil such as shear strength, bearing capacity which can be done by use of controlled compaction or addition of suitable admixtures like cement, lime, sand, fly ash or by providing geo textiles geo synthetics, etc. The new techniques of soil stabilization can be effectively used to meet the challenges of society, to reduce the quantities of waste, reducing useful materials from non-useful materials. Since the use of plastic in diversified forms such as chairs, bottles, polythene bags, etc., has been advancing speedily and its disposal has been a problem all the time regarding the environmental concern, using plastic as soil stabilizing could reduce the problem of disposing the plastic as well as increase the density and California bearing ratio (CBR) of soil in a economical way. The present day is focused to overcome the problems experienced in Kovilpatti, a district in Tamil Nadu. In the present study, an experimental program was conducted for stabilization of Black Cotton Soil

in the mentioned region with the utilization of plastic waste as soil stabilizer. Different contents of plastic strips (% by weights varying from 0% - 1%) are added to black cotton soil and the optimum percentage of plastic strips in soil was found out by conducting California Bearing Ratio Test.

Keywords: Black Cotton Soil, Swelling and Shrinking, California bearing ratio (CBR)

A STUDY ON FOUNDRY SAND AND M-SAND AS A REPLACEMENT OF FINE AGGREGATE IN CONCRETE

Dharshana D** Dinesh kumar S** Subash G** Boobala Krishnan K V*

** Students, Email: dharshuams@gmail.com

*Assistant Professor, Email: boobalakrishnan007@gmail.com

Dr. N.G.P. Institute of Technology, Coimbatore – 641 048,Tamilnadu, India.

Increasing rate of urbanization and industrialization has lead to over exploitation of natural resources such as river sand and gravels, which is giving rise to sustainability issues. It has now become imperative to look for alternatives of constituent materials of concrete. Waste foundry sand, a by-product of ferrous and non ferrous metal casting industries is one such promising material which can be used as an alternative to natural sand in concrete. In last few decades, several studies have been conducted to investigate the effect of addition of waste foundry sand as partial and complete replacement of regular sand in concrete. It has been found suitable to be used as partial replacement of sand in structural grade concrete. This paper presents the design of concrete mixes made with used-foundry sand as partial replacement of fine aggregates by 10%, 15% and 20% in M20 concrete mix. Various mechanical properties are evaluated (compressive strength, and split tensile strength).

Key words: Waste foundry sand, Concrete, workability, strength properties.

AN EXPERIMENTAL INVESTIGATION ON SELF MANIPULATING CONCRETE

Mohamed Ashfaque.S.M** Mathanprasad.GMr.M. Satheesh Kumar*

*Assistant Professor

** UG Students

Department of Civil Engineering

P. A. College of Engineering And Technology, Pollachi - 642 002

Today concrete is most widely used construction material due to its good compressive strength and durability. Depending upon the nature of work the cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain concrete. Plain concrete needs congenial atmosphere by providing moisture for a minimum period of 28 days for good hydration and to attain desired strength and also when pouring of concrete compaction places a vital role to segregate the concrete otherwise there will be a formation of voids. Any voids in concrete and any laxity in curing will badly affect the strength and durability of concrete. Self-manipulating concrete is one of the special concrete which can work itself. i.e., it compacted with its self-weight without any external vibration and internal curing takes place. This paper involves the use of shrinkage reducing admixture polyethylene glycol (PEG 400) in concrete which helps in internal curing, better hydration and strength and high performance super plasticiser as Viscocrete 5930 in concrete to increase the flow ability of concrete.

Keywords: Good Compressive Strength and Durability, Polyethylene Glycol (PEG 400), super plasticiserasViscocrete 5930.

EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIESOF PARTIAL REPLACEMENT OF CEMENT BY WOOD ASH ANDLIME POWDER

Mr. Yuvaraj ,S* V. Harini** F. Roger Mathew** V. CharanMohammed**MunirulHudha**

*Assistant professor , Email: yuvaraj.s@sece.ac.in

**Students , Email: harinisece@gmail.com

Department of Civil Engineering, Sri Eshwar College ofEngineering, Coimbatore.

In recent times concrete has been the most used material in construction in all the developing countries. Concrete which is fundamentally made up of coarse and fine aggregates, uses cement as binding material.Cement is a mixture obtained by burning calcareous and argillaceous material creates a lot of pollution in its production. Therefore finding alternatives

takes huge priority. In this experimental study, cement is partially replaced by wood ash and lime powder. Wood ash is the residual material obtained as a result of combustion of firewood waste and from combustion done in boilers at pulp and paper mills, steam power plants, and other thermal power generating facilities. Lime is a calcareous material. The use of this material reduce green house gas emission proportionately and result in a more "green concrete" through reduction of energy consumption For the study a total of 9 mixes were produced namely,M1, M2(L10), M2(L20), M2(L30),M3(WA10), M3(WA15), M3(WA20), M4(L20&WA15) Under the macro study, Compressive strength , Split tensile strength and Flexural strength tests were conducted to know the strength properties of different mixes at the age of 7,14 and 28 days respectively In this experimental study the results indicated that high strength has been achieved at 15% of woodash and 20% of lime powder replacements.Hence final mix of M4 is done using the above mentioned combinations and has attained higher strength

Keywords: Green House Gas Emission, Compressive strength , Split tensile strength and Flexural strength tests.

EXPERIMENTAL INVESTIGATION ON SELF COMPACTING CONCRETE WITH M-SAND AS FINE AGGREGATE

MuthuPriya P* Gaayathri D** Gokul S** Praveen**

*Head of the Deapartment,Email : hodcivil@drngpit.ac.in

**Student, Email :hariraina3@gmail.com

Department of Civil Engineering, Dr. NGP Institute of Technology, Coimbatore.

In this investigation, the strength analysis of partially replacing granite waste in fibre reinforced self-compacting concrete is studied and their characteristic is compared. The mix proportion is obtained as per the guidelines given by European Federation of producers and contractors of specialist's products for structure (EFNARC). SCC mixes are produced by replacing the cement with 10%, 20% and 30% of granite waste and with addition of glass fibre of 0.2%, 0.4%, 0.6%, 0.8% and 1% to the SCC concrete. The w/p ratio used in this investigation is 0.4. Super plasticizer used in this study is Conplast SP430 and its dosage is 0.5 % to obtain the required SCC mix. Fresh concrete properties are checked by conducting the workability tests such as Slump Flow, T50, L-Box, U-Box, V-Funnel tests. While there is abundant research information on ordinary confined concrete, there are little data on the behavior of Self-Compacting Concrete (SCC) under such condition. Due to higher shrinkage and lower coarse aggregate content of SCC compared to that of Normal Concrete (NC), its composite performance

under confined conditions needs more investigation. This project has been devoted to investigate and compare the mechanical behavior of confined concrete circular columns cast with SCC. The parameters affecting are including concrete compressive strength and confinement configuration.

Keywords: European Federation of producers and contractors of specialist's products for structure (EFNARC), Slump Flow, T50, L-Box, U-Box, V-Funnel tests.

DESIGN OF AN OPERA THEATRE WITH INNOVATIVE ACOUSTIC ABSORBING MATERIAL

ArkishembhaSohliya* KenliRina** Ashish Oommen Mathews** Godson Caleb**

An opera house is a theatre building used for opera performances that consist of a stage, an orchestra pit, audience seating, and backstage facilities for costumes and set building. These buildings are constructed specifically for opera and other performing arts. The term opera house/theatre is often used as a term of prestige for any large performing-arts center. The usage of artificial amplification usually reduces the originality of the performances. It has lower energy efficiency. The Opera Theatre is designed with minimum artificial amplification and using innovative acoustic absorbing material. The optimized use of reflector panels increase the audibility and originality of the sound produced at the stage. The walls of the theatre are curved to increase secondary reflections. The economic innovative materials are utilized to enhance absorption coefficient of the building. The use of Tinted glass for the roof decreases electricity consumption for lighting. The building is designed with focus on energy efficiency, aesthetic and functionality.

Keywords: Orchestrapit, Audience seating, and Backstage Facilities for costumes and set building.

STRUCTURAL EVALUATION OF FLEXIBLE PAVEMENTS

C Gajendran* Monica.P** Ponchitra.K**

*Associate Professor, Email :gajendranc@karunya.edu

**Students

Karunya Institute of Technology and Sciences, Coimbatore, Tamilnadu, India - 641114.

A distressed pavement requires maintenance. Maintenance measures constitute fresh investment on the existing roads. The maintenance expenditure can be reduced through proper planning, design, construction and quality control. If the causes of possible distresses are removed, or judiciously taken care of during design stage; the expenditure due to maintenance

measures on in-service roads reduces. This paper analyses the method of flexible pavement strengthening by BBD technique. The entire methodology and parameters involved in this technique are taken care of and lastly the design aspects of pavement strengthening are also put forth. This work is an attempt to study the BBD technique fully and then deduce the useful conclusions from the study and apply in field for strengthening of in-service pavements.

Keywords: Pavement, Judiciously, flexible pavement strengthening by BBD technique.

COMPARATIVE ANALYSIS ON PROPERTIES OF DIFFERENT GRADES OF FIBRE REINFORCED SELF COMPACTING CONCRETE

MuthuPriya P* HariPrasanth S** Muniraj S** Surya A** Loknath N A**

*Head of the Deapartment,Email : hodcivil@drngpit.ac.in

**Student, Email :hariraina3@gmail.com

Department of Civil Engineering, Dr. NGP Institute of Technology, Coimbatore.

In this Investigation the strength studies of fibre reinforced self-compacting concrete is studied and the characteristic is compared. The mix proportion is obtained as per the guidelines given by European Federation of producers and contractors of specialist's products for structure (EFNARC). SCC mixes are produced by replacing the cement with 30%, 40% and 50% of Fly ash to the SCC concrete. The w/p ratio used in this investigation is 0.4. Superplasticizer used in this study is Conplast SP430 and its dosage is 0.5% to obtain the required SCC mix. Fresh concrete properties are checked by conducting the workability tests such as Slump Flow, T50, L-Box, U-Box, V-Funnel tests. While there is abundant research information on ordinary confined concrete, there are little data on the behavior of Self-Compacting Concrete (SCC) under such condition. Due to higher shrinkage and lower coarse aggregate content of SCC compared to that of Normal Concrete (NC), its composite performance under confined conditions needs more investigation. This reserch has been devoted to investigate and compare the properties of different grades of Fiber Reinforced Self Compacting Concrete. The parameters affecting are including concrete compressive strength and confinement configuration.

Keywords: Fibre Reinforced Self-compacting Concrete, Conplast SP430

SEISMIC RETROFITTING OF BEAM-COLUMN JOINTS IN RC BUILDINGS USING JACKETING TECHNIQUES ALONG WITH CROSS BARS

J. PREMALATHA* LAKSHMIPRIYA N**

* Professor and Head

**PG-Student

Department of Civil Engineering

Kumaraguru college of technology

An analytical study on seismic retrofitting of a reinforced concrete Beam-column joint. The beam column joint is the critical zone in reinforced concrete structures. Recent earthquakes have demonstrated that most of the reinforced concrete structures were severely damaged during earthquakes and they need major retrofitting works. The main objective of this study is to increase the shear capacity and load carrying capacity of the structures using retrofitting techniques. In this study, the retrofitting was done by jacketing methods like carbon fibre reinforced polymer sheets (CFRP), Glass fibre reinforced polymer mesh, Sisalfibres along with crossed bars are carried out using the ANSYS Workbench. The wrapping of beam column joint was done by single, double, triple layer of CFRP, GFRP and Sisal fibres with different thickness. During the analysis one end of the column were fixed. Cyclic loading was applied at the mid of the cantilever beam in Beam-column joint and Fixed load was applied at the top of the column. The load is applied up to the ultimate load to obtain the fatigue failure. This report discusses about the performance of the retrofitted beam column joint; and was compared with the conventional specimen.

Keywords: Seismic Retrofitting, Carbon Fibre Reinforced Polymer Sheets (CFRP), Glass Fibre Reinforced Polymer Mesh, Sisal Fibres.

STRENGTH OF CORRUGATION IN ROOFING SHEETS WITH VARIOUS FIBRES

Sukrithi.S*Aravinthkumar.R**Muthukaruppan.V**Tamilarasi.N**

**Students, Email :karthika84688@gmail.com

*Assistant Professor, Email :sukrithi.rajan@gmail.com

Department of Civil Engineering, Dr.N.G.P Institute of Technology, Coimbatore

Most of the corrugated roofing sheets have damaged due to tearing out at its corrugations by high wind loads and impact loads. The strength of these corrugations can be improved with fiber reinforcement, as the fibers are the crack arresters and absorbs energy. In this study fiber

namely polyester, glass fiber, coconut coir fiber and fly ash are used as reinforcement in cement matrices for producing corrugated roofing sheets has been investigated and reported. Polyester, glass fiber, coconut coir fiber and fly ash roofing sheets were cast manually and the strength of the corrugations of the above composite sheets in terms of splitting due to impact loads, water absorption test and flexure test, were experimentally evaluated. It is found that the strength towards splitting of corrugations of the polyester, glass fiber, coconut coir fiber and fly ash corrugated roofing sheets due to impact loads and bending strength was improved as compared to the corrugated sheets without fibers. The result of the study revealed that fibers like polyester, glass fiber, coconut coir fiber and fly ash can be used to replace asbestos, in the production of corrugated roofing sheets.

Keywords: Corrugated sheets, Polyester, Glass fibre, Coconut coir, Impact load.

PARTIAL REPLACEMENT OF CEMENT BY FLYASH AND GLASS FIBRE REINFORCEMENT

Senthilrajan M* Deepika S** Gowtham G**ShamsuddinTagala**

*Assistant Professor, Email: senthilrajan@drngpit.ac.in

**UG Students, Email: meynadeepu@gmail.com

Dr. N.G.P. Institute of Technology, Coimbatore – 641 048,Tamilnadu, India.

Fly ash can be used as a mineral admixture in cement and concrete. Using it provides several advantages such as improved strength and workability properties, and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions. Alkali Resistant glass fibers are used as additional reinforcement of constant 0.4% by weight of cement. Glass fibers acted as a good crack arrester and increases split and flexural strength, but not show good results in compressive strength.M20 grade of concrete is used for this study. The main objective of this work is to study the suitability of the fly ash as a mineral admixture for cement replacement and additional reinforcement of glass fibers in concrete. Fly ash as partial replacement of cement and glass fibers are used as additional reinforcement which satisfies the various structural properties of concrete like compressive, split tensile and flexural strength. From the entire study it is concluded that mix M1 (40%FA + 0.4 % of GF) is the best combination among all mixes, which gives maximum tensile strength. There is no increased compressed strength at 7 days and split tensile strength in fly ash mixes.

Keywords: Fly ash (FA), Alkali Resistant Glass Fiber (GF), Workability, Compressive strength, Split tensile strength, Flexural Strength.

STRENGTHENING OF GREEN CONCRETE USING NATURAL FIBER

C. Chandrasekar* G.Karthikeyan**

* Assistant Professor,

** PG Student

Department of Civil Engineering,

Dr.SivanthiAditanar College of Engineering,Tiruchendur.

Today, Concrete is the most widely used Construction material used due to its good compressive strength and durability. Conventional Concrete in which Cement has been used as binder which releases large amount of heat during hydration process which also causes the atmosphere pollution also degrade the quality of environment also the other issue deals in Conventional Concrete is not economical due to increasing demand of Fine aggregate and Cement. The aim of the investigation is to produce green concrete which is economical and also improving strength comparing to normal Concrete. In M25 grade concrete, Cement is replaced constantly by 15% of Fly ash and Fine aggregate is replaced varyingly by Copper Slag as 10%, 20%, 30%, 40% and 50%. Totally 6 cubes , 3 prisms and 3 cylinder have been cast for each ratio Mechanical strength like Compression Strength , Flexural Strength, and Split Tensile strength are performed from which the average value can be estimated.

Keywords: copper slag, fly ash, sisal fiber.

UTILIZATION OF NON-DESTRUCTIVE ADDITIVES IN HIGHLY COHESIVE SOIL FOR STABILIZATION

Raja.G* Arulsurya.M** Anbarasan.K** Dhanasri.A** Indhumathi.V**

*Assistant Professor

**UG Student

Dept. of Civil, Angel College of Engineering and Technology, Tirupur.

This paper investigates the utilization of non-Destructive Additives in highly cohesive soil to stabilization. Highly cohesive soil stabilized with copper slag that is produced from the process of smelting of copper these slags are mechanically concentrated before smelting contains iron oxides

and silicon oxides. The addition of copper slag reduces the shrinkage of the cohesive soil.And further polypropylene fiber is added for the uses of increases the shear strength of the soil.The ratio of each Admixtures were obtained in terms of percentage ranges from (1% to 4%) and the laboratory investigation is performed for the admixture treated soil with 16 difference ratios.The detail observation of swelling and shrinkage behavior of clay soil is assessed in a consecutive manner.Similarly, The variation in the strength;hydraulic conductivity deformation characteristics were also observed.The test results showed that copper slag and polypropylene significantly changes the strength characteristics, swelling and strength properties of the clay soil.

Keywords: Cohesive Soil, Copper Slag, Iron Oxides and Silicon Oxides.

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Dr. N.G.P. - Kalapatti Road, Coimbatore - 641 048, INDIA | Phone : 0422 - 2369105
Fax : 0422 - 2369106 | E-mail : info@drngpit.ac.in I Web : www.drngpit.ac.in