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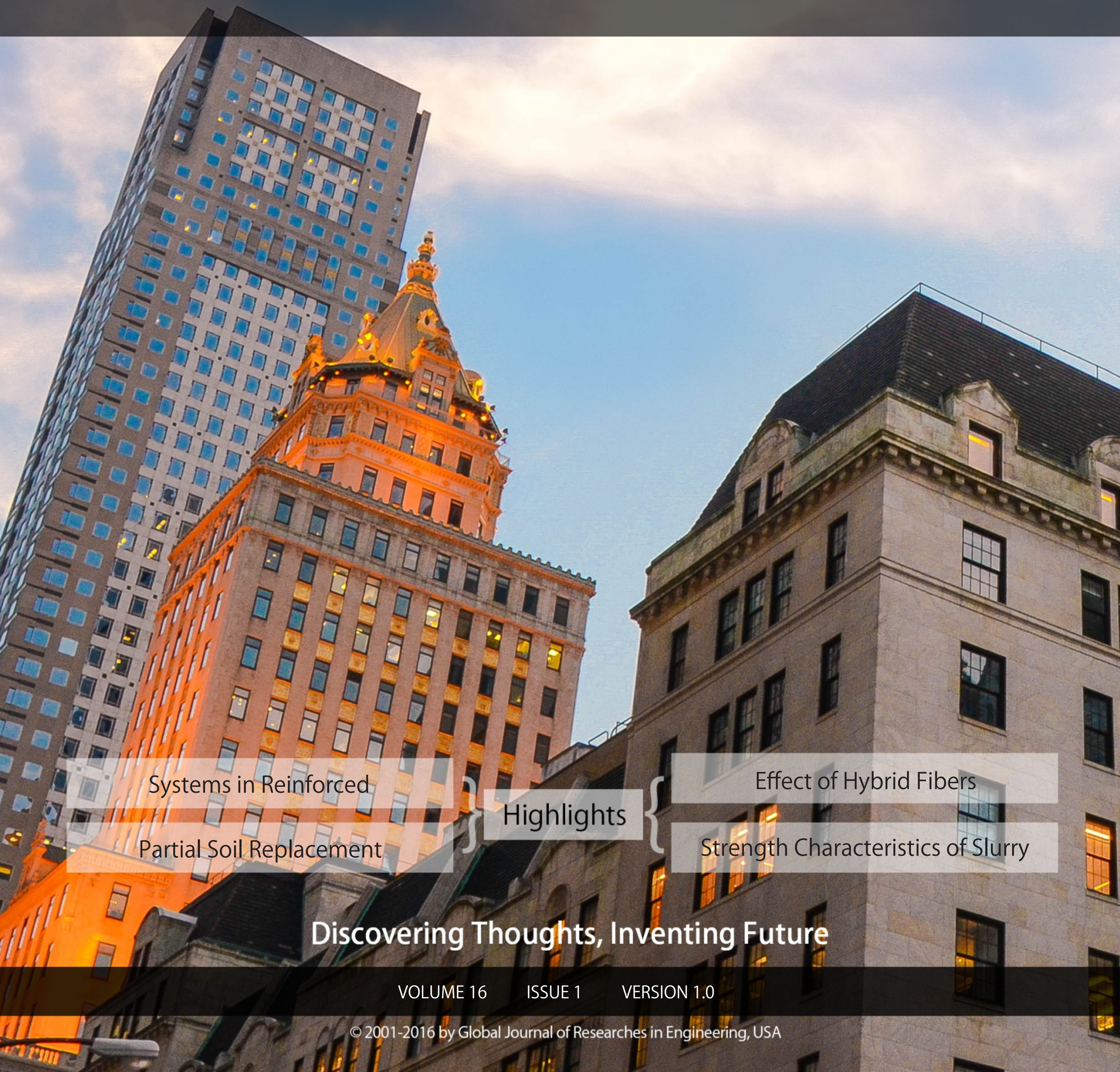

Systems in Reinforced

Partial Soil Replacement

Highlights

Effect of Hybrid Fibers

Strength Characteristics of Slurry

Discovering Thoughts, Inventing Future

VOLUME 16 ISSUE 1 VERSION 1.0

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Effect of Hybrid Fibers on the Strength Characteristics of Slurry Infiltrated Fibrous Ferrocement with Partial Replacement of Steel Fiber by Polypropylene Fiber and with Partial Replacement of Natural Sand by Manufactured Sand

By G. S. Sudhikumar, Ulagadde Chandrashekhara & Chethan Kumar A.C
Chennabasaveshwara Institute of Technology, India

Abstract- The concrete composites play an important role in the field of concrete. The addition of fibers to concrete enhances the strength properties and ductility characteristics. The use of two or more type of different fibers in sustainable combination has potential to improve the mechanical properties of concrete and results in performance synergy. This combination of fibers, often called hybridization of fibers. The inclusion of fibers into concrete not only provides considerably more ductile structure but also improves the structural properties such as tensile strength, static flexural strength, impact strength, flexural toughness and the energy absorption capacity of the high strength concrete. Ferrocement is light weight and versatile material having high cracking, ductility and fatigue resistance and is additionally impermeable to make it far superior than reinforced concrete. It is used for prefabricated residential units, marine and industrial structures. Slurry infiltrated fiber concrete (SIFCON) could be considered as a special type of fiber concrete with high fiber content. The matrix consists of cement slurry or flowing.

Keywords: ferrocement, fibers, fiber reinforced concrete, hybridization; slurry infiltrated fibrous ferrocement (SIFF), welded mesh, chicken mesh, compressive strength, flexural strength, impact strength.

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Effect of Hybrid Fibers on the Strength Characteristics of Slurry Infiltrated Fibrous Ferrocement with Partial Replacement of Steel Fiber by Polypropylene Fiber and with Partial Replacement of Natural Sand by Manufactured Sand

G. S. Sudhikumar [α], Ulagadde Chandrashekhara [σ] & Chethan Kumar A.C [ρ]

Abstract- The concrete composites play an important role in the field of concrete. The addition of fibers to concrete enhances the strength properties and ductility characteristics. The use of two or more type of different fibers in sustainable combination has potential to improve the mechanical properties of concrete and results in performance synergy. This combination of fibers, often called hybridization of fibers. The inclusion of fibers into concrete not only provides considerably more ductile structure but also improves the structural properties such as tensile strength, static flexural strength, impact strength, flexural toughness and the energy absorption capacity of the high strength concrete. Ferrocement is light weight and versatile material having high cracking, ductility and fatigue resistance and is additionally impermeable to make it far superior than reinforced concrete. It is used for prefabricated residential units, marine and industrial structures. Slurry infiltrated fiber concrete (SIFCON) could be considered as a special type of fiber concrete with high fiber content. The matrix consists of cement slurry or flowing cement mortar. This composite material withstands blast loading and can be used for pre-stressed concrete beams and safe vaults. Slurry infiltrated fibrous ferrocement (SIFF) is a combination of SIFCON and ferrocement and can overcome the limitations of latter. SIFF can be used for the structures like runways in aerodromes, industrial floors etc.

This paper deals with an experimental investigation on the strength characteristics of Slurry infiltrated fibrous ferrocement with partial replacement of 1.5% steel fiber by polypropylene fiber and with 60% replacement of natural sand with manufactured sand.

The results indicated that with 10% replacement of steel fiber with polypropylene fiber improve the compressive strength marginally as compared to mono fibers. Where as, hybridization improves the flexural strength noticeably.

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Keywords: ferrocement, fibers, fiber reinforced concrete, hybridization; slurry infiltrated fibrous ferrocement (SIFF), welded mesh, chicken mesh, compressive strength, flexural strength, impact strength.

I. Introduction

Today, concrete fiber composite is the most promising and cost effective material used in the construction. Many researchers have shown that the addition of small closely spaced and uniformly dispersed fiber to concrete transforms the brittle cement composite into a more isotropic and ductile material called fiber reinforced concrete (FRC).

In RCC the strength makeup is in the direction of reinforcing bars. In a structure where the tensile stresses are omni-directional, the reinforcing becomes difficult and expensive. FRC which is made up of thin fibers dispersed randomly in all the directions impart strength to its entire volume.

FRC can be used in the preparation of various precast building units such as cladding sheets, window frames, roofing units, floor tiles, manhole covers and advanced applications in highway pavements, air field, machine foundations, industrial floorings, bridge deck overlays, sewer pipes, earthquake resistant structures and explosive resistant structures (like MX missile silos etc).

Even though the performance of FRC in pavement, air fields, industrial floors and machine foundations is satisfactory, it has some limitations. It cannot be employed where high impact, vibration, wear and tear are expected. Many problems have to be faced during the construction of FRC, especially when the quantity of fiber used is more. The fiber should be dispersed uniformly in concrete for being effective. The fibers if put in bulk along with other ingredients do not disperse, but nest together and is called balling effect.

The balling effect can be reduced to some extent by mixing the fibers and other ingredients in dry form and then adding water. The fibers present in the concrete may block the discharge port. Since the flow of FRC is low, the FRC has to be placed near to the place where it is to be used finally. Its spreading with rakes and spades is difficult and laborious. With compaction fibers realign, such that they tend to concentrate more near the surface. Therefore the compaction has to be controlled.

Similar to FRC, Ferro cement – Environmentally sound technologies, according to agenda 21, protect the environment, are less polluting, use all resources in a more sustainable manner [1] has also many advantages and its applications are rapidly increasing in the precast construction industry. Ferro cement make use of different types of steel meshes for its construction. Ferro cement is a form of reinforced mortar wherein the reinforcement is distributed spatially all through the mortar with smaller diameter wire mesh at a very close spacing [2]. Ferro cement also suffer from limitations. It cannot be employed where high impacts, vibrations, wear and tear are expected. The strength of the fibrocement increases with the increase in the number of wire mesh layer and method of confinement [3] and steel content. But when the reinforcement is more, the mortar cannot be easily forced inside without forming voids. Thus strength of fibrocement reduces.

The fibrous fibrocement, which is a combination of fiber reinforced concrete and fibrocement, can overcome all the above said limitations to some extent and can be employed with assurance where high impacts, vibrations, wear and tear are expected. In this new material the advantage of both fibrocement and fiber reinforced concrete are combined. The fibrous cement is becoming a promising material for bridge overlays and industrial floorings where high impacts, high vibrations and high wear and tear are expected. The reinforcements used in fibrous fibrocement are of three kinds. The first type reinforcement is welded mesh where smaller diameter bars (approx. 12 G) are kept closely in both directions and are spot welded. This mesh gives stability and shape to the structure. The second type reinforcement is chicken mesh. This is mesh of similar wires (approx 20G) which are interwoven to different openings. The spacing between the wires of chicken mesh is small. This mesh mainly distributes the stresses evenly and the cracks will be minimized. The third type of reinforcement is fiber. The fibers may be of steel, carbon, glass, polypropylene, GI etc. Experiments have shown that, addition of 1.5% steel fibers with 60% replacement of natural sand by manufactured sand have increased the strength and ductility properties [4]. These fibers act as crack arresters and are randomly distributed in the concrete [5].

Depending upon the shape required, the cage is prepared out of welded mesh and chicken mesh. The cage can be prepared by tying the chicken mesh over the welded mesh at regular intervals by using binding wires. The calculated quantities of fibers are placed in the mould. The mortar is then infiltrated into the mould to form SIFF.

II. Materials and Method

Main objective of this experimentation is to study the strength characteristics of slurry infiltrated fibrous fibrocement with varying percentage replacement of 1.5% steel fiber with polypropylene fiber with 60% replacement of natural sand by manufactured sand. The aspect ratios of steel fiber used was 25, and that of polypropylene fiber was 1600. Different strength parameters considered for study are compressive strength, flexural strength and impact strength.

Ordinary Portland cement of 43 grade and locally available sand (passing 1.18 mm and retained on 150 micron IS sieve) with specific gravity 2.64 was used in the experimentation. To impart additional workability a super plasticizer (Conplast SP 430), 1% by weight of cement was used. The welded mesh (WM) used in the experimentation was square opening of 25 mm x 25 mm of 20 gauge. The chicken mesh (CM) used was having a hexagonal opening with 0.5 mm diameter. The cement mortar with a proportion of 1:1 was used with a water cement ratio of 0.45.

The required size of welded mesh and chicken mesh were first cut according to the mould sizes for compression, flexural and impact tests. The chicken mesh was tied to the welded mesh using binding wires at regular intervals. This forms the cage (1WM + 1CM). Cages were prepared by tying the chicken mesh layer to welded mesh at regular intervals by using binding wire. The prepared cages were placed in the moulds which were oiled. Cement –sand slurry was prepared with a mix proportion of 1:1 with a w /c ratio of 0.45, and a super plasticizer dosage of 1% (by weight of cement).

For steel fibers, initially a small quantity of slurry (10 mm) was poured into the mould and then the respective cages were placed in the mould and then the fibers were placed in the mould and later on the slurry was infiltrated up to the brim level and was lightly compacted using the table vibrator. Whereas for polypropylene fibers, fibers were initially dispersed in the dry cement-sand mortar and then water of required amount was added, after placing the cages, slurry was filled into the mould and then lightly compacted. Then the moulds were covered with wet gunny bags for 12 hours. After 12 hours, the specimens were demoulded and kept in water for 28 days curing. For compressive strength, specimens of dimensions 150 x 150 x 150 mm were cast. For flexural strength, specimens of dimensions 100 x 100 x 500 mm were cast. For impact strength, specimens of diameter 152 mm and thickness 63.5 mm were casted. The specimens were demoulded after 24 hours of casting and specimens were transferred to curing tank for 28 days. After 28 days of curing, they were taken out of water and were tested for their respective strengths.

III. Test Results

a) Test Results of Compressive Strength

Following table 1 gives the overall results of compressive strength of slurry infiltrated fibrous errocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand. The variation in the compressive strength is represented graphically in figure1.

Table 1 : Compressive strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

Percentage replacement of steel fiber by polypropylene fiber	Compressive strength (MPa)	Percentage increase / decrease of compressive strength w.r.t ref mix
0 (Ref.mix)	40.20	-
10	41.77	03..90
20	35.42	-11.89
30	33.51	-16.66
40	30.53	-24.05
50	30.40	-24.37
60	26.40	-34.32
70	20.10	-50.00
80	19.86	-51.59
90	19.33	-51.91
100	18.53	-53.90

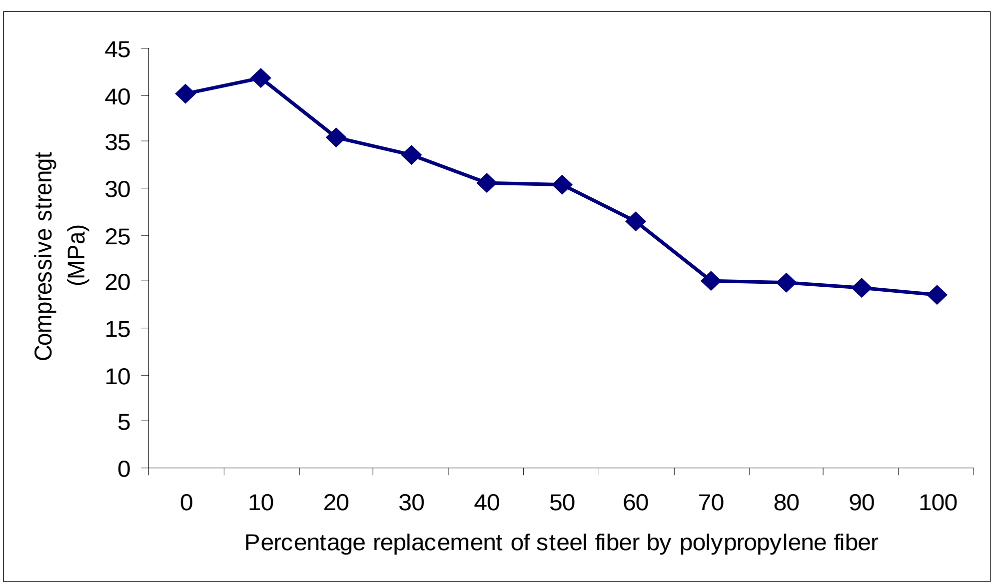

Figure 1 : variation of Compressive strength of slurry infiltrated fibrous fibrocement with partial replace mentof steel fiber by polypropylene fiber.

b) Test Results of Flexural Strength

Following table 2 gives the overall results of flexural strength of Slurry infiltrated fibrous fibrocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand. The variation in the flexural strength is represented graphically in figure1.

Table 2 : Flexural strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

Percentage replacement of steel fiber by polypropylene fiber	Flexural strength (MPa)	Percentage increase / decrease of flexural strength w.r.t ref mix
0(Ref. mix)	4.00	-
10	7.30	81.65
20	6.20	55.00
30	5.60	40.00
40	5.40	35.00
50	5.00	25.00
60	4.20	05.00
70	2.70	-33.33
80	2.60	-35.00
90	2.48	-38.00
100	2.40	-41.60

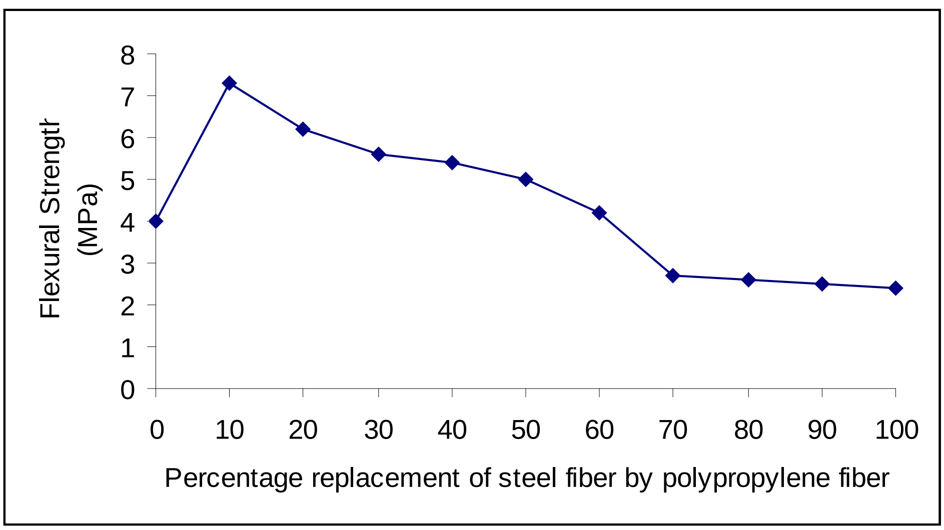

Figure 2 : Variation of Flexural strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

c) Test Results of Impact Strength

Following table 3 gives the overall results of impact strength of Slurry infiltrated fibrous ferrocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand. The variation in the impact strength is represented graphically in figure3.

Table 3 : Impact strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

Percentage replacement of steel fiber by polypropylene fiber	Impact strength required to cause (N-m)		Percentage increase / decrease of impact strength w.r.t ref mix	
	First crack	Final failure	First crack	Final failure
0(Ref.mix)	15695.00	18644.04	--	--
10	16967.50	19633.82	8.10	05.30
20	13089.20	17916.90	-16.60	-03.90
30	12887.20	15645.53	-10.00	-16.08
40	12584.22	13352.00	-19.82	-28.38
50	12422.63	13271.00	-20.84	-28.81
60	11897.44	13210.40	-24.19	-29.14
70	11635.00	13150.00	-25.86	-29.46
80	10584.50	12665.00	-32.56	-32.12
90	9453.32	11453.00	-39.76	-38.57
100	7857.60	9776.50	--50.00	-47.56

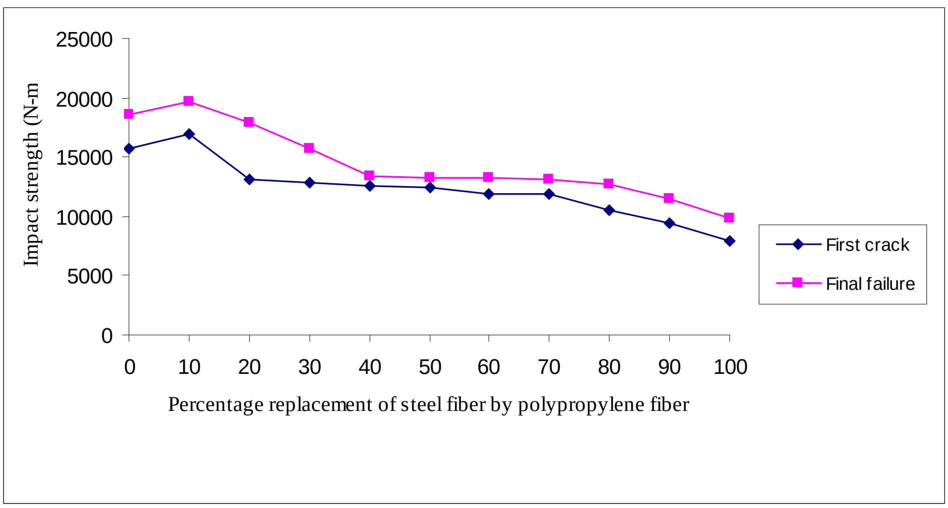

Figure 3 : Variation of impact strength of slurry infiltrated fibrous ferrocement with partial replaceme of steel fiber by polypropylene fiber.

IV. Discussion on Test Result

Following observation were made with reference to partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand.

It is clear from the test result that the compressive strength, flexural strength and impact strength of slurry infiltrated fibrous ferrocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60 % replacement of natural sand by manufactured sand goes on increasing upto 10% replacement of steel fiber by polypropylene fiber, there after strength decreases. A higher compressive strength of 41.77 Mpa (Table 1), flexural strength of 7.3 Mpa (Table 2) and impact strength of 16967.50N-m, 19633.82 N-m and (Table 3) for the first crack and final failure respectively. In other words, the percentage increase in compressive strength were to be 03.90 %, (Table 1), flexural strength were to be 81.65% , (Table 2) and impact strength were to be 8.10% and

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The reason for this can be attributed that 10 percent replacement of steel fiber by polypropylene fiber will certainly increase the microcrack resisting capacity of slurry infiltrated fibrous ferrocement and with 60% replacement of natural sand by manufactured sand, thus resulting in higher compressive, flexural and impact strength.

V. Conclusions

Following conclusions can be drawn based on the study conducted on the effect on the strength characteristics of Slurry infiltrated fibrous ferrocement with partial replacement of 1.5% steel fiber by polypropylene fiber and with 60% replacement of natural sand with manufactured sand.

It was observed that the compressive, flexural and impact strength increases upto 10 percent replacement of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand, thereafter the strength decreases. This may be due to the fact that, 10 percent replacement of polypropylene fiber may arrest the micro cracks which can contribute to the strength of concrete.

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Controlling Collapsibility Potential by Partial Soil Replacement

By Naema.A. Ali

King Marrito Institute for Engineering, Egypt

Abstract- At or near saturation, collapsible soils undergo a rearrangement of their grains and water removes the cohesive (or cementing) material. In Borg El Arab, near Alexandria Egypt, soils exhibit high susceptibility for collapse when saturated. In this paper, inundation stress has been applied to investigate its effect on the collapse potential and permeability behavior of Borg El Arab soil. Because of the collapse of soil when wetted low bearing capacity and rapid substantial settlement are developed and makes it unsuitable as foundation soil or pavements sub-base in their natural condition. The collapsible soil may be treated by remove and replace method to improve strength. Experimental program was developed to explore the effect of types of compacted replacement on collapsibility potential. A series of tests were carried out to search for the most suitable types of partial replacement and the location of source of surface wetting to evaluate their effects on the reduction of settlement of a footing on collapsible soil when inundation occurs. The results show that inundationstress have strong effect on collapse potential and permeability coefficient. The behavior of a shallow foundation rests on compacted sand / crushed stone layers as partial replacement over treated collapsible soil by pre-wetting and compaction is investigated.

Keywords: collapse; collapse potential; compressibility; improved; replacement soil.

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CONTROLLINGCOLLAPSIBILITYPOTENTIALBYPARTIALSOILREPLACEMENT

Strictly as per the compliance and regulations of :

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Keywords: collapse; collapse potential; compressibility; improved; replacement soil.

I. Introduction and Literature Review

Problematic collapsible soils exist in many parts of the world, both naturally and as a result of man-made activity, thus making their behavior a truly global problem. In general wetting induces volume changes, and leads to changes in strength and stiffness. When significant amounts of water are introduced into the soil, the collapse settlements are usually amplified. Man-made compacted fills, may also develop a collapsible or metastable structure at low density. Collapsible soils are sensitive to changes of porosity and moisture content. Their volume usually decreases with the increase of moisture content especially when much water reaches the soil and sometimes under practically unchanged total vertical stress. Common causes of wetting are meanly human activities in regions having collapsible soils so that which makes the hazards posed. Many researchers reported that lack of knowledge in the construction industry with respect to identification, behavior and treatment of collapsing soils led to many cases of foundation problems, (Houston, et al 2001, Ayadat, T. and Hanna, A.,2007, 2013, Hawraa, et al 2012). In literature, little or no attempts were made to develop a rational soil classification technique based on the most governing parameters of soil collapse behavior. Collapsible soils have been widely studied for more than 70 years resulting in a broad wealth of literature. As their name indicates, these soils can exhibit large volume change upon wetting, with or and sometimes without extra loading, thus posing significant challenges to the geotechnical profession, (Houston, et al 2002).

Pereira et al. (2000) summarized the factors that produce collapse as follows: ‘‘1. an open, partially unstable, unsaturated fabric, 2. a high enough net total stress that will cause the structure to be metastable, 3. a bonding or cementing agent that stabilizes the soil in the unsaturated condition, and 4. the addition of water to the soil, which causes the bonding or cementing agent to be reduced and the inter granular contacts to fail in shear, resulting in reduction in total volume of the soil mass.

’’Numerous case histories pertaining to the problems caused by collapsible soils have been reported in the literature, (Rogers, et al 1994, Al-Rawas, A.A 2000, El Kholy, M.S. 2008 and Soliman, et al. 2010). In addition to the problems posed to buildings and embankments, challenges related primarily to differential settlements are encountered also in the construction of roads on collapsible soils.

Many studies are performed on geotechnical behavior of collapsible soil in different countries and reported that the problems induced by collapsible soils require consideration of the following four important issues: 1. identification and characterization of collapsible soils, 2. assessment of collapse potential and settlement; 3. estimation of the distribution and degree of wetting in the deposit; and 4. evaluation of design alternatives and mitigation strategies. While as the literature on collapsible soils is quite extensive, there

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are significant voids that still need to be filled. An area that appears to require further work pertains to the (rapid) identification and characterization of these soils. Fundamentally, point of view, much investigation still is to be learned on the mechanisms responsible for the collapse. Finally, a more general approach for the selection of mitigation/ improvement methods to deal with these soils is also needed, (Telford, et al, 1990, Al-Rawas, A.A 2000 and Houston, et al 2001). During inundation, as the percentage of water in the pore spaces increases, matric suction decreases and the bond of matrix suction diminishes.

In Egypt, recent extensions of urban communities towards the desert, where collapsible soils may exist pose significant challenges to the geotechnical profession. Construction of foundations on collapsible soil is considered one of the outstanding problems in geotechnical engineering. The main geotechnical problem associated with collapsible soils is the significant loss of shear strength and volume reduction occurring when they are subjected to water from any source of water. Generally, collapsible soils are under partially saturated or dry conditions have negative pore pressure resulting in higher effective stress and high shear strength.

In this study a series of experimental work was conducted to present the engineering techniques of Borg El Arab collapsible soils improvement by removal and partial replacement with thickness equal to foundation width, (Abdel-Mohsen, H.H., and Ali, A.N. 2014, 2015 and Ali, A.N. 2015), pre-wetting and pre-compression, which resulted in densification, and increase of bearing capacity reduction of its settlement. A series of experimental work was conducted on improved collapsible soil to study the performance of different types of partial replacement of cohesionless materials and their effect on the reduction of settlement when inundated. The problem of wetting inducing collapse involves many uncertainties related to soil variability, source of surface wetting and to the primary source of driving stress (overburden, structural, or both). A series of tests were carried out to search for most types of replacement and the location of wetting source to evaluate their effects on the reduction of settlement of a footing on collapsible soil when inundation occurs. The lack of knowledge in the construction industry about the identification, behavior and treatment of collapsing soils is believed to have had led to many cases of either foundation problems.

II. Soil Characteristics

The odometer test (ASTM D5333-03) was used to study the soil collapse potential. The influence of the particle size distribution, void ratio and density on the soil collapsibility was also, studied using (ASTM) standard procedures on the undisturbed soil samples. These samples have been collected from different locations located in Borg EL-Arab area near Alexandria city, north of Egypt to determine their geotechnical properties. Table 1 shows geotechnical properties based on results of a laboratory testing program on undisturbed soil samples recovered from test sites.

Table 1 : Index properties and collapsibility potential of undisturbed soil samples from Borg EL-Arab region

Soil properties	Sample 1	Sample 2
Initial Water Content (%)	6.3	6.8
Natural Unit Weight (kN/m^3)	13.8	14.6
Percentage of Sand	36.2	40.2
Percentage of Silt	58.4	53.6
Percentage of Clay	5.4	6.2
Collapsibility Potential C_p (%)	11.6	12.0

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III. Laboratory Model and Experimental Procedures

Assembly of test equipment is shown in Figure 1. A soil bin used to contain the soil is a square tank 600mm × 600mm internal dimensions and 700 mm high. The four sides of the tank are transparent plastic (Perspex) plates with 12 mm thickness braced with steel angles to prevent lateral movements of tank sides during placing and compacting the soil and loading. The base of the bin is a square steel plate with 40 mm thickness.

The loading system consists of rigid steel frame supporting a steel lever with 1020 mm length connected to steel columns by a pivot, Figure 1. Steel shaft is attached with a proving ring to transmit the load by the lever. Proving ring has 2 KN maximum capacity and 2N accuracy. The loads were applied incrementally via the loading lever using standard dead weights. Circular model footings 80 mm diameter and 30 mm thickness were used. The vertical settlement of the loaded footing was measured by mechanical dial gauges of 0.01 mm accuracy which were fixed rigidly to dial gauge holders, (Abdel-Mohsen, H.H., and Ali, A.N., 2015).

An elevated water tank connected to a distribution device through a plastic tube was used to inundate the tested soil. Water was then placed in the tank and controlled to allow to seepage to the soil surface via flexible plastic pipes. The uniformity distribution of water on soil surface was ensured by equal length and diameter of flexible plastic pipes connecting the inlet and outlet nozzles, equal diameter of inlet nozzles attached to the tank's base and outlet nozzles attached to the water distributing steel grid in four columns and four rows. By adjusting the soil surface in a horizontal level, a uniform distribution of outlet nozzles on soil surface was guaranteed to drop the water around the footing model. It was noticed that there was no water head retained above the soil surface, figure 1.

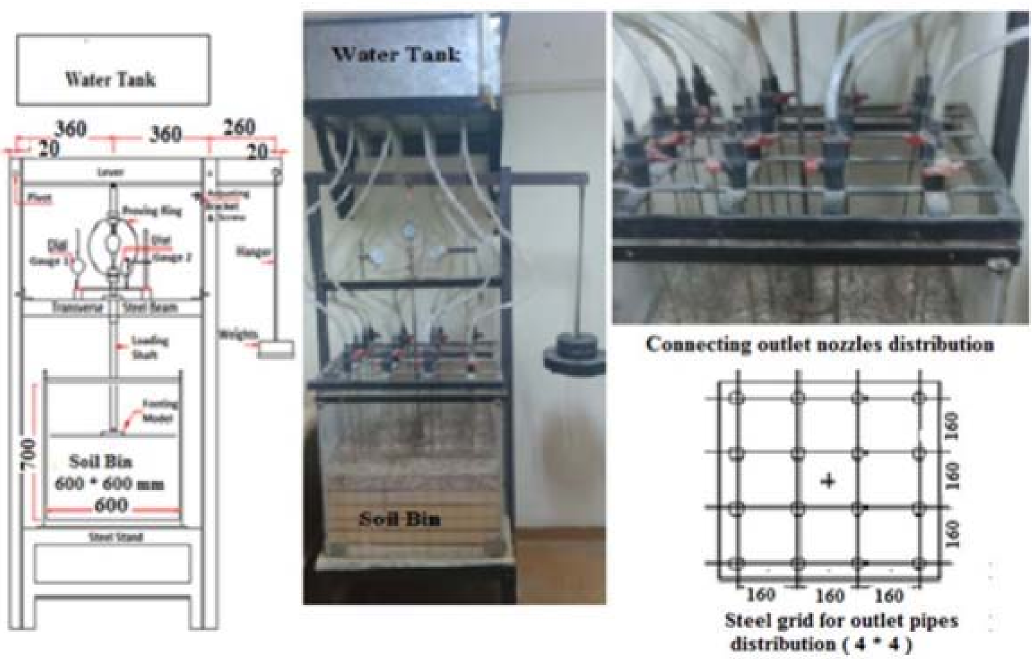

Figure 1 : Test Equipment

The study is a part of detailed investigation program designed to examine the collapsibility potential of Borg EL-Arab collapsible soils and to search for a suitable method to mitigate their potential risk upon wetting. In the current laboratory study, a footing model was loaded up to failure on partially replacement cohesionless materials on improved subgrade using pre-wetting and compaction.

Basic laboratory tests were carried out on undisturbed soil samples representing the collapsible soil which were collected from different locations to determine geotechnical and physical properties. Improved compacted samples have maximum dry unit weights which varied between 16.8 kN/m3 and 17.8 kN/m3 with corresponding optimum water content varying between 16.2% and 17.3%. Compacted samples were prepared at dry unit weight of 98% of the maximum dry unit weight determined by Modified Proctor Test.

IV. Sample Preparation

Dry soil is mixed with a certain percentage of water and placed in the bin in relatively thin layers, each 50 mm thick up to a predetermined height, which is 400 mm height inside the bin. Water was carefully mixed with the soil to the desired water content. Replacement cohesionless soil used in this study are, sand, mixture of crushed stone and sand, crushed stone and mixture of fine crushed stone and collapsible soil with different percentages. The artificially soil samples were prepared by mixing disturbed extracted samples with (20, 40 and 60)% of fine crushed stone. The soil is prepared outside the container and mixed thoroughly with 17% of water optimum moisture content. The mixture is poured into the container in two layers, each 40 mm. A static compaction method was applied to prepare sets of identical samples of unit weight 17.8 kN/m3 and relative compaction 95% of modified Proctor compaction. The replacement sample was directly compacted into the bin to reach a thickness of about 80 mm (equal to footing diameter D).

Circular footing of steel 80 mm diameter and 30 mm thickness was used and centered on top of the replacement layer. Vertical loads were applied incrementally via loading lever, for each and load, settlement was recorded with time till it ceased, after which next increment was applied. The problem of induced collapse due to wetting involves many uncertainties related not only to the soil variability, but also to the source of wetting and to the primary source of driving stress. To study the wetting / inundation effect, soil was inundated with 4000 cm3 of water which was allowed to seep on the soil surface via flexible plastic pipes, to simulate inundation in field due to rain fall or excessive irrigation and/or leakage from water and / or sewer lines. Soaking stage of sample was found to take one day wetting the soil from top to bottom. To simulate inundation in field due to access of water from different sources water was allowed to seep on the soil surface via one or two rows of flexible plastic pipes through controlled tubes at distances D and 3D; where D is the footing diameter. For each test, the water was allowed to seep through the soil to a specified elapsed time of 1 hr., 6 hrs., 12 hrs., 24 hrs., 48 hrs. and 72 hrs. to study differential soil collapse and localized collapse of foundation nearest to leakage. In these tests the penetrated water in compacted improved collapsible soil was measured, and soil specimens to determine their water content were taken at different depths through the horizontal soil surface at many locations. The depths of soil specimens were measured using scale of 1.0 mm accuracy.

Seven groups of tests were designed to study the effect of different types of partial replacement of cohesionless materials with thickness equal to diameter of footing placed on top of improved compacted collapsible soil layer upon inundation and different imposed stresses. The designed testing program is summarized in Table 1.

Table 1 : Test program

Effect of different types of partial replacement of cohesionless materials 1.0 D thickness on compacted improved collapsible soil	
Group A Types of replacement layer (Dry)	Sand Sand / crushed stone mixture 2:1 crushed stone
Group B The treatment of collapsible soil by mixing it with fine coarse graind soil	The mixtures prepared from a mix of excavated collapsible soil with fine crushed stone in different percent (20, 40, 60)%
Effect of inundation on treatment of soil	
Group C Inundated with 4000 cm^3 of water (rain fall)	Effect of inundations on different type of cohesionless
Group D Inundated with 4000 cm^3 of water with applied stress =150 kN/m^2	replacement layer and mixtures of collapsible soil with fine crushed stone in percentages of 60% with thickness 1.0 D placed on compacted improved collapsible soil.
Group E Inundated with 4000 cm^3 of water Soaked at different stresses 50, 100, 150 kN/m^2	Effect of inundations in sand replacement layer with thickness 1.0 D on compacted improved collapsible soil at stress =100 kN/m^2
Group F Inundated with 4000 cm^3 of water Soaked at different thickness of improvement collapsible soil at stress 100 kN/m^2	Effect of inundations on different thickness of compacted improved collapsible soil (4D≈350mm & 6D≈500mm) under replacement sand layer with thickness 1.0 D at stress =100 kN/m^2
Group G Inundated with 4000 cm^3 of water pipes at distance D and 3D from footing in both sides. Footing stress during inundation =100 kN/m^2.	Effect of inundations form different sources of water on replacement layer with thickness 1.0 D on compacted improved collapsible soil at stress =100 kN/m^2 to simulate water leaking from broken water lines or utility line leakage.

V. Results and Discussion

Figure 2 shows the relationship between applied pressure and settlement of the collapsible soil improved by using partial replacement with different types of cohesionless soil with thicknesses equal to diameter of footing under concentric loaded footing, group A. It can be noticed that the bearing capacity increases with partially replacing collapsible soil with different cohesionless soils. The bearing capacity also increases with increasing the weight and stiffness from replacement sand to mixed sand and crushed stone to crushed stone. For the four cases under study the estimated ultimate bearing capacity values are 320, 575, 605 and 645 kN/m2 respectively for compacted collapsible soil, sand, Sand / crushed stone mixture 1:2 and crushed stone with thicknesses t=D, figure 2. Generally high strength subgrades materials are placed near surface on which load is applies because the intensity of stress under footing decreases with depth. The experimental work conducted for employed the mixture of removed collapsible soil with different percentages of fine crushed stone (20, 40, 60)%, as a partially replacement layer rest on improved collapsible soil by pre-wetting; test group B. Figure 3 shows that by adding the fine crushed stone to collapsible soil has significantly influenced the allowable applied pressure and reduced settlements that is at the same applied pressure the settlement is lower. The largest reduction in settlement was achieved with the increase of percentage of added crushed stone. The settlement decreased with the increase of percentages of fine crushed stone mixed with the collapse soil. From three cases under study the estimated ultimate bearing capacity values are 320, 360, 460 and 520 kN/m2 respectively with the different percentage of fine crushed stone mixed. As shown in fig. (3), an increase in the percentage of fine crushed stone mixed with collapsible soil from 0% to 60% reduced the footing settlement and increased the estimated ultimate bearing capacity, with increase of 0.125, 0.43 and 0.62 respectively. The largest increase in bearing capacity was achieved at the largest percentage of added fine crushed stone which is 60%.

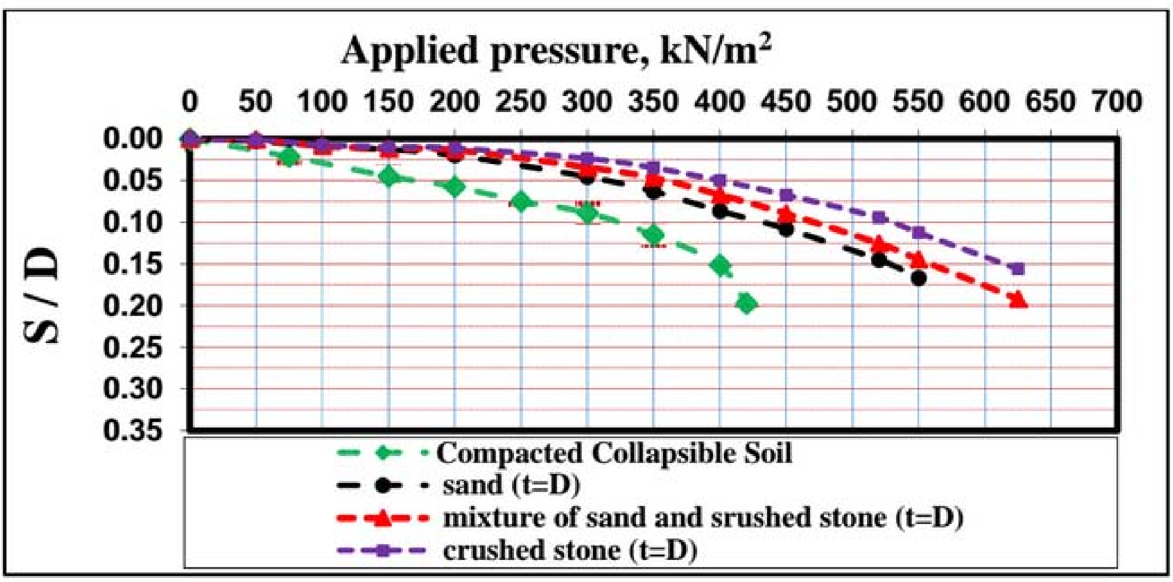

Figure 2 : Settlement versus applied vertical stress for different types of cohesion-less replacement soil before flooding

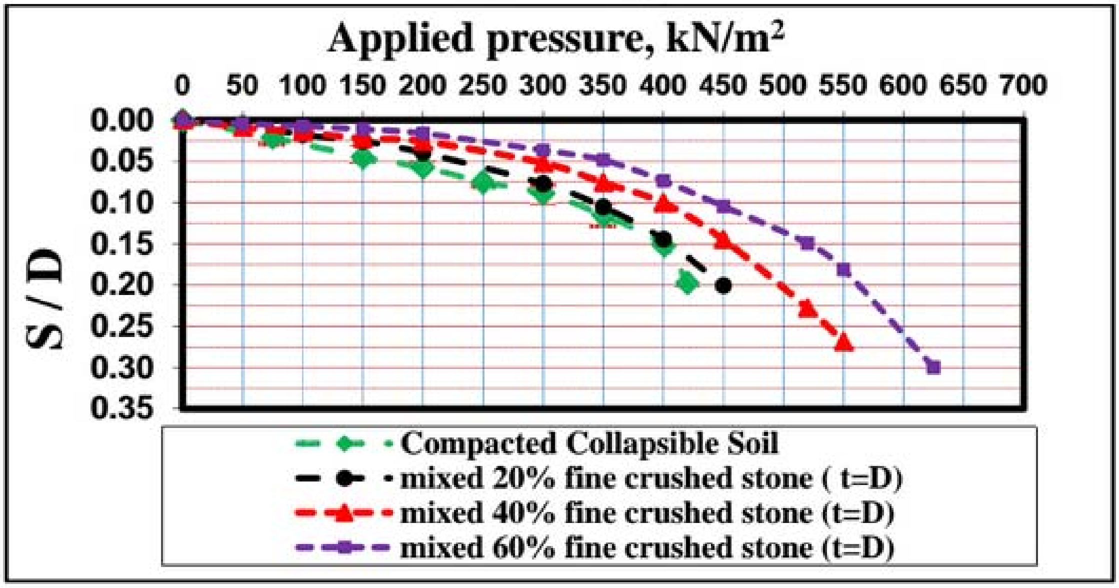

Figure 3 : Settlement versus applied vertical stress for different percentages of fine crushed stone added to collapse soil and using as layer of replacement soil before flooding

Causes of immediate/ sudden foundation failure due to inundation of collapsible soil are identified based on pressure-settlement curves. The demonstration of pressure-settlement response of collapsible soil, in relation to the change in soil moisture, guides the practicing engineers to obtain a safe design load on foundation and its type. Figures 4 and 5 present relationships between applied pressure and settlement of the footing collapsible soil after inundation (test groups C and D). After soaking, the bin is left for 24 hours to ensure that all soil was completely soaked. The load was then applied to failure, which was indicated by the increase of settlement rate at a nearly constant load intensity. From figures, it is quite clear that replacement on top of improved collapsible soil presents better footing performance in terms of settlement against applied stress. Due to inundation, the estimated ultimate bearing capacity values decreases to 290, 425, 460 and 520 kN/m2 for the four cited combinations respectively with reduction of 0.10, 0.26, 0.24 and 0.19 respectively. The results indicated that the wetting of compacted soil significantly increases the expected footing settlement under the effect of load, and this settlement decrease when the material under footing has a high elastic modulus.

Figure 5, indicates that the estimated ultimate bearing capacity values decreases by flooding to 290, 320, 410 and 480 kN/m2 respectively with reduction of 0.10, 0.11and 0.077 respectively. The non-collapsibility nature of compacted fine crushed stone, may counteract the process of collapsibility through surface friction among soil particles. It is noticed that the increase of fine crushed stone percent to collapsible soil reduced its collapse to one half. As shown in figures, the influence of soil wetting on foundation settlement decreases abruptly when replacement material has a high stiffness and high elastic modulus. With such replacement, collapse due to wetting was greatly reduced or eliminated, irrespective of the compaction water content.

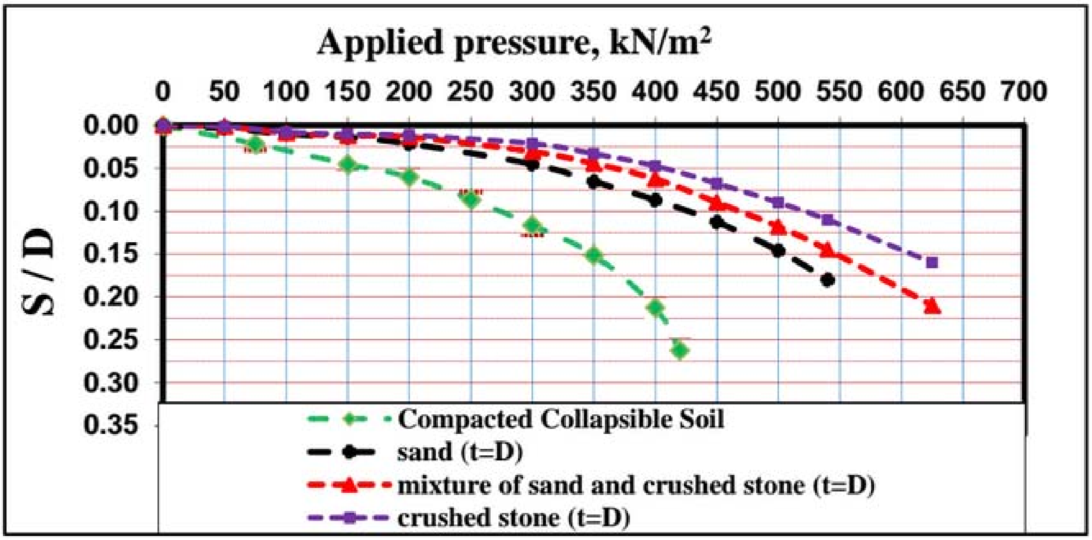

Figure 4 : Settlement versus applied vertical stress for different types of cohesionless replacement soil after flooding

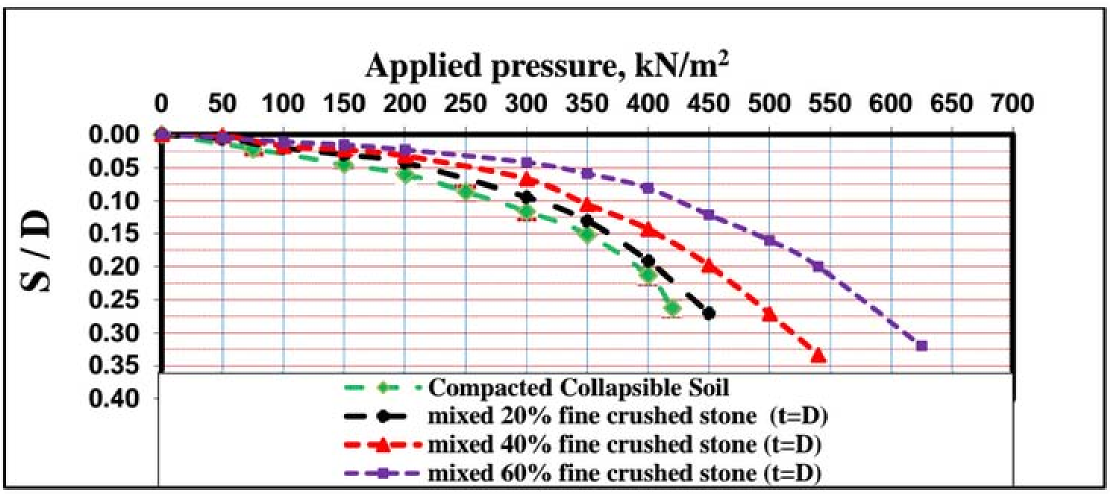

Figure 5 : Settlement versus applied vertical stress for different percentages of fine crushed stone added to collapsible soil and using as layer of replacement soil after flooding

The problem of wetting inducing collapse involves many uncertainties related not only to the soil variability, but also to the source of wetting and to the primary source of driving stress (overburden, structural, or both). A series of conducted tests involved loading to stress levels representative of the overburden stresses and expected field load to study the collapsibility potential. In tests of group E, during flooding the pressure was kept constant until collapse settlement has ceased. The results presented in figures 6 through 9 show the compressibility for the purpose of different improvements of collapsible soil. There are gradual decreases in volume with additional wetting which will led to an increase of water content of soil. Figures 6 through 8 show that using partial replacement cohesionless with higher value of stiffness reduced the collapse settlement of the footing and resulted in higher ability to resist higher value of applied stress than the compacted improved collapsible soil without partial replacement. Collapse potential was affected by applied stresses, the grater the applied stress the grater the collapse potential during wetting. Collapsing increased continuously with applied stress. Collapsing of treated soil with using partial replacement of cohesionless soil is less than that of partial replacement of mixed with 60% fine crushed stone treated soil with the same thickness at different stresses. Using fine crushed stone mixed with excavated collapse soil added more effect in reducing the collapse settlement of the footing and increased the bearing capacity.

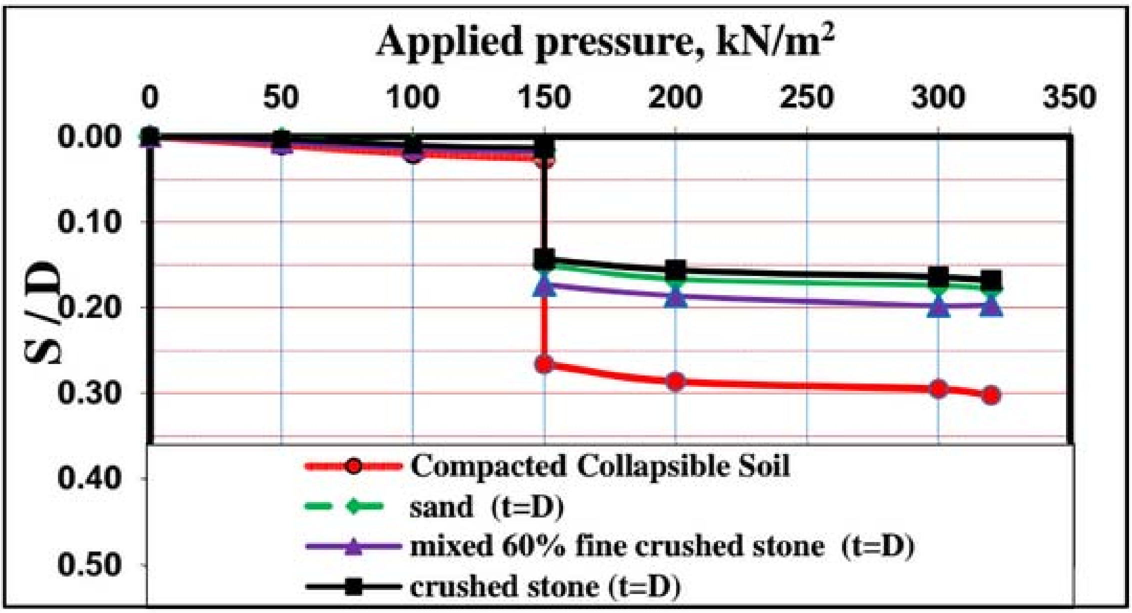

Figure 6 : Settlement versus applied vertical stress on the flooding at stress 150 kN/m2

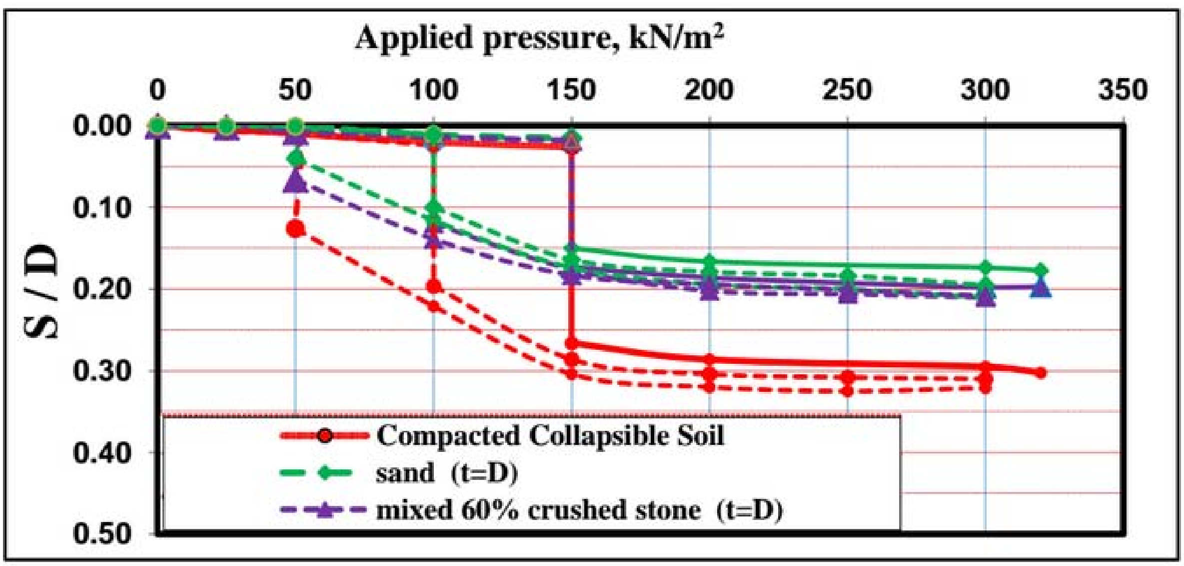

Figure 7 : Settlement versus applied vertical stress for different levels of inundation stresses

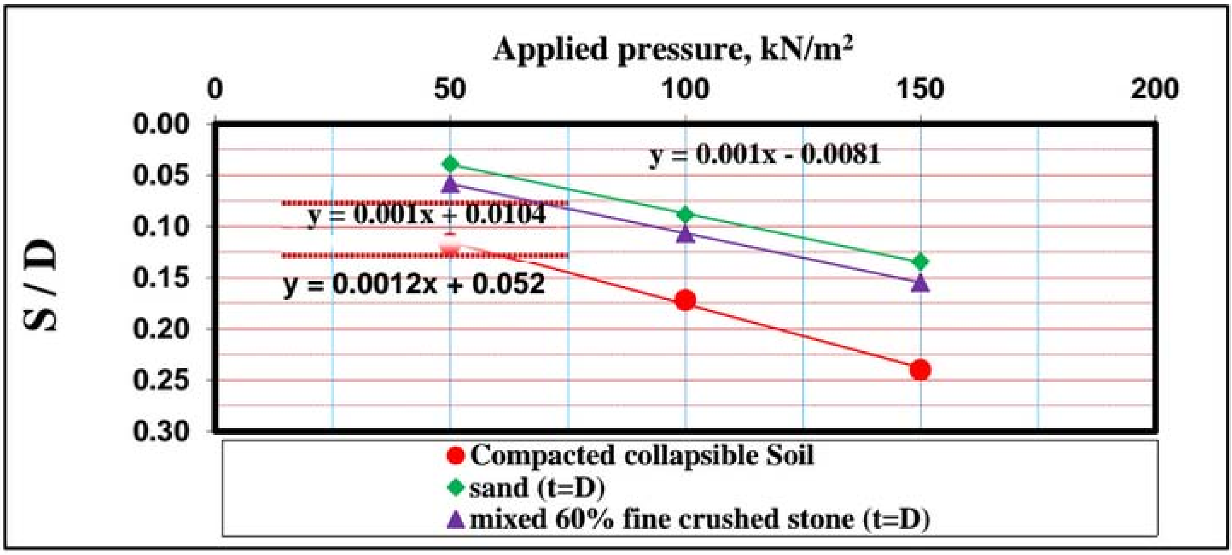

Figure 8 : Settlement versus applied vertical stress for different levels of inundation stresses

Figure 9 shows the settlement of the soil with time as it is related to penetrated water to depth of compacted improved collapsible soil under replacement layer. Collapse settlement increases due to an increase of soil collapse applied stress level on the foundation and decreases due to the increase of stiffness and elastic modulus of partial replacement layer under footing. The results showed the effect of the percentage of fines content in soil, coefficient of permeability and suction gradient. When saturated, collapsible soils undergo a rearrangement of their grains and the water removes the cementing material. Quick substantial settlement causes an increase in surface water infiltration. Higher conductivity of replacement layer allows great lateral movement of water which can result in wetting of the surface to considerable distance away from the source of wetting. The deeper wetting associated with lateral movement of water also suggests that any sources of water that is far laterally through the soil profile (either on-site or off-site) must be taken into consideration. This suggests that site drainage is an important factor to be considered during design and construction. If rainfall runoff ponds exist throughout a site with no sediment and runoff control, infiltration from water ponds may induce failure. Also, subsurface drains, top and interceptor drains shall be provided as a requirement in engineering standards. The structural stability of collapsible soils is related to suffuse process, which is a process of lateral and vertical removal of the fine soil particles by subsurface flow and often leads to settlement.

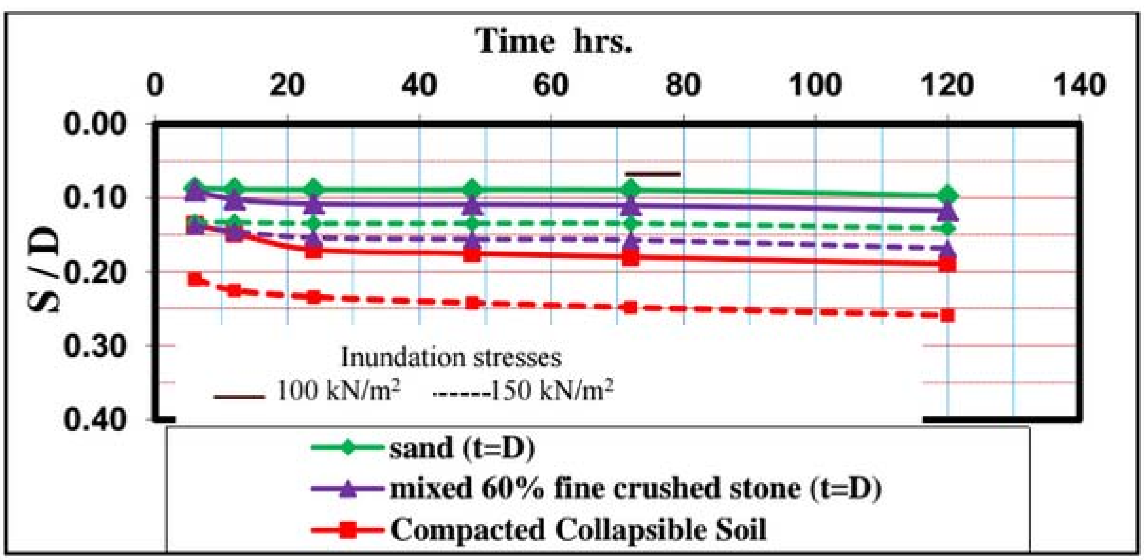

Figure 9 : Settlement – time at applied vertical stress on the flooding at stresses 100 / 150 kN/m2

A series of tests conducted involved different thickness of improved collapsible soil to study the effect of inundation on thickness of compacted improved collapsible soil (4D≈350mm & 6D≈500mm) under partially replaced sand layer with thickness 1.0 D at stress 100 kN/m2(tests group F). The change in soil moisture with depth guides the practicing engineers to design load on foundation. Figures 10 and 11 show the degree and depth of wetting during inundation. The results show the effect of the percentage of fines content in soil which lose their collapsible characteristic by compaction and assist in reducing the amount of water penetration into the subgrade, coefficient of permeability and suction gradient. There are gradual decrease in volume with additional wetting which leads to an increase of water content of soil. Collapse settlement was affected by the thickness of improved collapsible soil. The grater the depth of collapsible soil, the grater the collapse settlement, was observed. Naturally occurring routes of downward movement of soil loaded with water was observed. Another term for collapsible soils is "hydro-comp-active soils" because they compact after water is added. The amount of collapse depends on the thickness of the soil that becomes wetted. Thus these collapse soil require special consideration that is unique to regions where deep or thick layers of collapse soil are present.

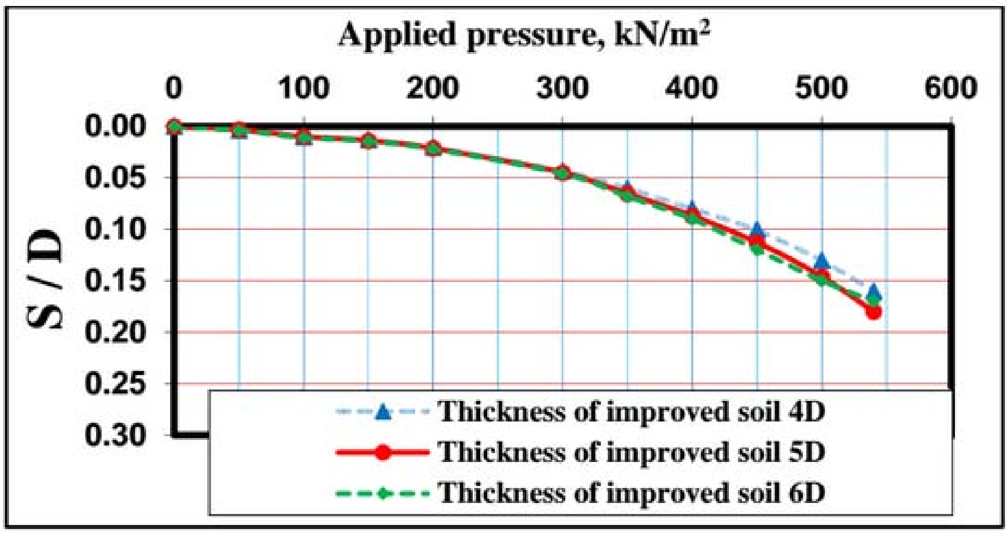

Figure 10 : Settlement versus applied vertical stress after flooding

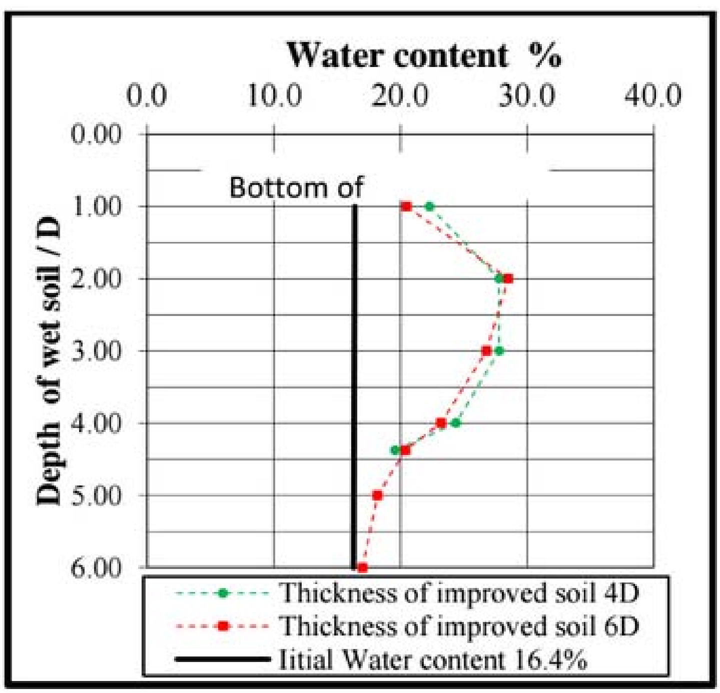

Figure 11: Variation of water content with depth in improved soil

Foundation movement problems are mostly associated with water existence and therefore, it is imperative that the investigation of the sources of water be the first order of distress investigation. Thus a series of tests conducted involved different sources of inundation, thickness of improved collapsible soil under replacement equal to 6D (tests of group G). Inundated soil with 4000 cm3 from water pipes at distance D and 3D from footing on both sides of footing under a stress during inundation =100 kN/m2 to simulate water leaking from a broken water / sewer lines or utility line leakage.

Figures 12 through 14 shows that wetting may reduce or soften bond or cementation between soil particles leading to their rearrangement near the water source causing differential soil collapse. Figures show that the total amount of collapse potential depends on the environmental conditions, such as the extent and duration of wetting, and the pattern of moisture migration.

Figure 13 and 14 indicate that compressibility of improved soil before inundation is low and increase gradually during inundation with time. After seven days the increase in collapse settlement under foundation resulting from nearest source of water is greater than that of the second source at the same time; although the inundation in the two cases uses the same amount of water (4000 cm3). This result may be due to amplified collapse settlement supplemented by consolidation settlement induced by the significant increase in soil unit weight resulting from the addition of water. Thus providing a minimum of ten percent surface slope outwards from foundation may be considered as prudent a suitable protective measure.

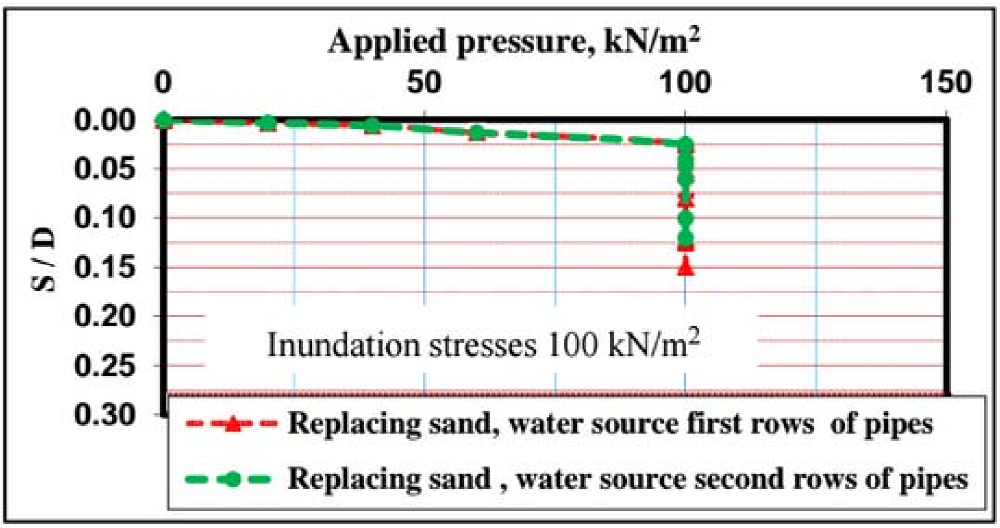

Figure 12 : Settlement versus applied vertical stress on inundation at stress 100 kN/m2

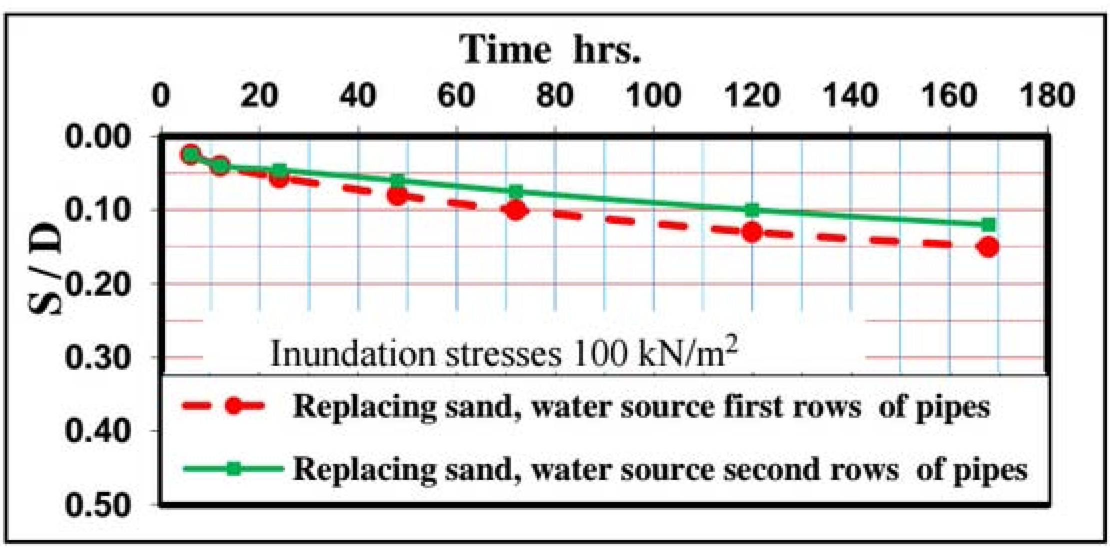

Figure 13 : Settlement versus time at applied vertical stress on the flooding at stress 100 kN/m2

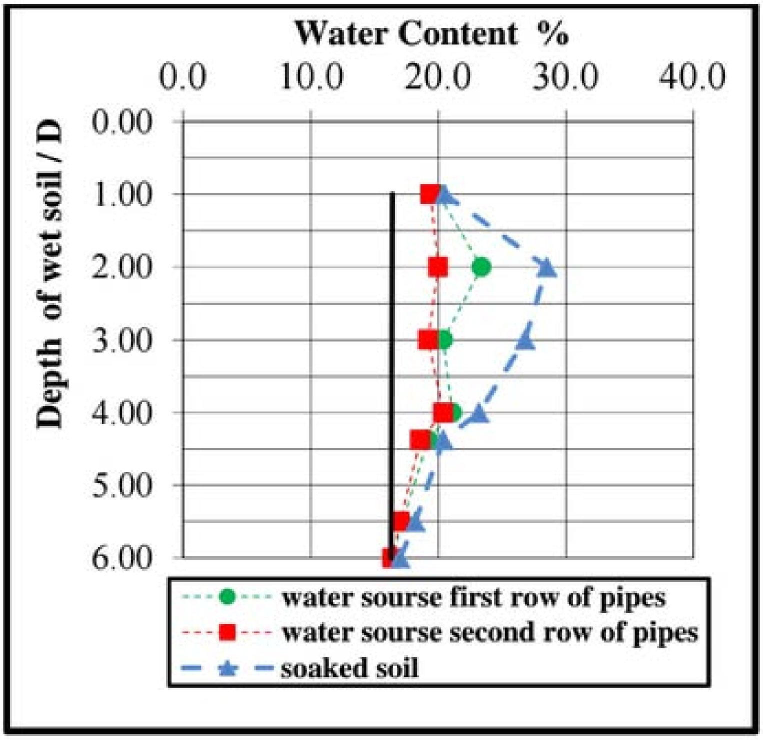

Figure 14 : Water content along improved soil depth

Figure 14 shows the variation of water content before and after wetting with depth under footing which explained an increase in the collapse settlement with time. For this study case, water penetration reached as far as 5.5 footing diameter.

VI. Conclusion

Based on the results, conducted investigation and analyses the following conclusions can be advanced:

- Removal of some thickness of collapsible soil and replacing it by cohesionless soil and altering surface and subsurface drainage patterns of water on collapsible soil improve the stability of collapsible soil formation. The soil partially replaced with compacted cohesionless soil in this study reduces the foundation settlement by about 50% and increased bearing capacity by about (80-100%).
- Adding fine crushed stone to collapsible soil has significantly influenced the results concerning applied pressure and settlement relationships; at the same applied pressure the settlement is significantly lower. The largest reduction was achieved at the largest percentage of added fine crushed stone (60%). The settlement decreased with the increase of the crushed stone percentages mixed with the collapse soil.
- An increase in the percentage of fine crushed stone mixed with collapsible soil from 0% to 60% reduced the footing settlement and increases the monitored ultimate bearing capacity by increase of 0.125, 0.43 and 0.62 for the three mixed respectively. The largest increase in bearing capacity was achieved at the largest percentage of added fine crushed stone 60%.
- Collapse potential of treated collapsible soil by using partial replacement of cohesionless soil decreases with the increase of stiffness of replacement material and with increase of high elastic modulus near the footing load.
- The collapse of compacted improved soil is more than of the cases using partial replacement of cohesionless soil. Collapse potential was affected by the applied stress, the greater the applied pressure, the greater the collapse caused during wetting, collapse increased continuously with the increase of applied stress.
- The severity of the collapse depends on the extent of wetting, depth of the deposit and load from the overburden and structure. Predicting settlements due to collapsible soil is difficult due to several factors including sample disturbance problems, variability of the subsoils, extent of wetting and variable loading conditions. Settlement estimates are generally made by considering the collapse over the potential depth of wetting. The settlements typically occur along the perimeter of the structure and are differential. Relatively severe settlements and building distress have been experienced where the collapsible soil depth is greater.
- Results proved that improvement of collapsible soils is possible to mitigate their risk potentials against

sudden settlement when exposed to wetting, and provide remediation for design and construction oversight.

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Seismic Evaluation of Multi Storey RC Buildings with and without Fluid Viscous Dampers

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Strictly as per the compliance and regulations of :

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I. Introduction

a) General

Earthquakes are one of the most destructive of natural hazards. Earthquake occurs due to sudden transient motion of the ground as a result of release of energy in a matter of few seconds. The impact of the event is most traumatic because it affects large area, occurs all of a sudden and unpredictable. Vibrations induced in the earth's crust due to internal or external causes that virtually shake up a part of the crust and all the structures and living and non-living things existing on it they can cause large scale loss of life, property and disrupts essential services such as water supply, sewerage systems, communication, power and transport etc. The aftermath leads to destabilize the economic and social structure of the nation. The primary objective of earthquake resistant design is to prevent building collapse during earthquakes thus minimizing the risk of death or injury to people in or around those buildings. Earthquake forces are generated by the dynamic response of the building to earthquake induced ground motion. This makes earthquake actions Fundamentally different from any other imposed loads. Dynamic responses are stresses, strains, displacement, acceleration etc. The design of buildings for seismic loads is special, when compares to the design for gravity loads (dead loads and live loads). Gravity loads are relatively constant, in terms of their magnitude and are treated as 'static' loads. In contrast, seismic loads are predominantly horizontal (lateral), reversible (the forces are back-and-forth), dynamic (the forces rapidly vary with time) and of very short duration. The seismic loads are more uncertain than the conventional gravity loads in terms of magnitude, variation with time and instance of occurrence. The variations of the forces with time affect the resistance of the building. The maximum magnitudes of the internal forces and their locations in the structural members are different from those due to gravity loads. In order to make a building seismo-resistant, it should have good building configuration, lateral strength, lateral stiffness, ductility, stability and integrity. Data obtained from the NESDIS National Geophysical Data Centre, Significant Earthquake Database. Table 1.1 shown the Loss of Life and Property Damage for Recent Earthquake Disaster

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Table.1.1 : Loss of Life and Property Damage for Recent Earthquake Disaster

Location	Date	Magnitude	LossofLife	Property Damage
Northridge	17/01/1994	6.8	60	$20billion
Kobe,Japan	17/01/1995	6.8	5,502	$147 billion
Kocaeli, Turkey	17/08/1999	7.8	15,637	$6.5billion
Chi-Chi,Taiwan	28/09/1999	7.7	2,400	$14billion
Bhuj,India	26/01/2001	8.0	20,005	$4.5billion

b) Structural Control

Structural control is a diverse field of study. Structural control is one area of current research that looks promising in attaining reduce structural vibrations during loading such as earthquakes and strong winds. The reducing of structural vibrations occurs by adding a mechanical system that is installed in a structure. Structural control for civil structures was born out of a need to provide safer and more efficient designs with the reality of limited resources. The purpose of structural control is to absorb and to reflect the energy introduced by dynamic loads such as winds, waves, earthquakes and traffic. Today, the protection of civil structures from severe dynamic loading is typically achieved by allowing the structures to be damaged.

$$E=E_k+E_s+E_h+E_d \qquad (1.1)$$

Where E is the total energy input to the structure from the excitation, Ek is the kinetic energy of the structure, Es is the elastic strain energy of the structure, Eh is the energy of the structure dissipated due to inelastic deformation (e.g, allowing damage to the structure), and Ed is the energy dissipated by supplemental damping devices. For traditional structures, the right hand side of the equation (1.1) includes only Ek, Es and Eh. By including the energy term Ed through structural control, the energy dissipated by supplemental damping devices, the kinetic, elastic and most importantly, the inelastic deformation energy can be reduced, preserving the primary structures.

There are three primary classes of supplemental damping devices, categorized into three corresponding control strategies. The first class of supplemental damping devices is passive. Passive devices are non-controllable and require no power. The second class of supplemental damping devices is active. Active devices are controllable, but requires significant power to operate. The third class of supplemental damping devices is semi active. Semi active devices combine the positive aspects of passive and active control devices in that they are controllable (like the active devices) but require little power to operate.

c) The Effect of Different Values of α, the Velocity Exponent

Figure 1.1 shows the hysteresis loop of a pure linear viscous damper when subjected to a sinusoidal input. The loop is a perfect ellipse. The absence of storage stiffness makes the natural frequency of a structure incorporated with the damper remain the same. This advantage will simplify the design procedure for a structure with supplemental viscous dampers.

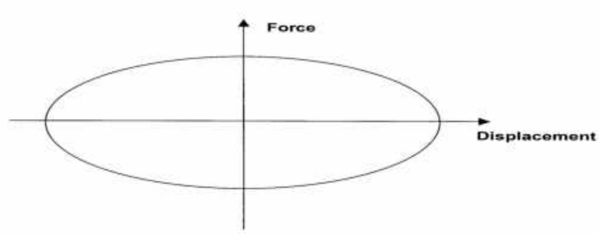


Figure 1.1: Hysteresis loop of viscous damper

Fluid viscous dampers have the unique ability to simultaneously reduce both stress and deflection within a structure subjected to a transient. This is because a fluid viscous damper varies its force only with velocity, which provides a response that is inherently out-of-phase with stresses due to flexing of the structure. The ideal force output of a viscous damper can be expressed as

$$FD=C|u.|\alpha\ \mathrm{sign}(u.)$$

Where FD is the damper force, C is the damping constant, u. is the relative velocity between the two ends of the damper, α is the exponent between 0 and 1. The damper with α=1 is called as a linear viscous damper in which the damper force is proportional to the relative velocity. The dampers with α larger than 1 have not been seen in the practical applications. The damper with α smaller than 1 is called as a non-linear viscous damper which is effective in minimizing high velocity shocks. The below figure 1.2 shows the force velocity relationships of the three different types of viscous dampers. This figure demonstrates the efficiency of non linear dampers in minimizing high velocity shocks. For a small relative velocity, the damper with a α value less than 1 can give a larger damping force than the other two types of dampers.

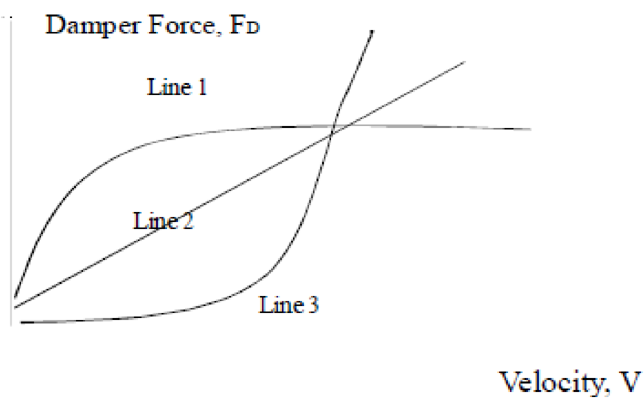


Figure 1.2 : Force- Velocity Relationship Viscous Damper

Line 1: FD=CN1 Vα , Non-linear damper with α >1.
Line 2: FD=CL Vα , Linear Damper.
Line 3: FD=CN2 Vα , Non-linear damper with α<1.

d) Placement of FVDs in a structure

Having determined the target building performance and required damping contribution to the response, the designer must identify appropriate locations to install the dampers. Often this is in the form of diagonal braces in which the damper device is placed in-line with the brace member. However as demonstrated by Constantinou et al. [1] and Şigaher and Constantinou [2], there are a many configurations that could be considered which can avoid significant architectural and functional compromise. The key point is that the damper must connect to points in the structure that have differential motion when the building sways. This motion can be either horizontal or vertical depending on the primary lateral force resisting system and the inherent deformed shape of the structure. The use of 'toggle-brace' configurations can significantly increase the velocity applied to the damper using geometric amplification as shown in figure 1.3, and this corresponds to improved efficiency of the damper in terms of lateral force resistance and energy dissipation. Such setups can be used to reduce the size of the damper, or improve the damping effect on the structure. It should be noted however that experimental studies on toggle setups have generally not achieved the calculated efficiencies due to the brace and connection flexibility reducing the velocity amplification.

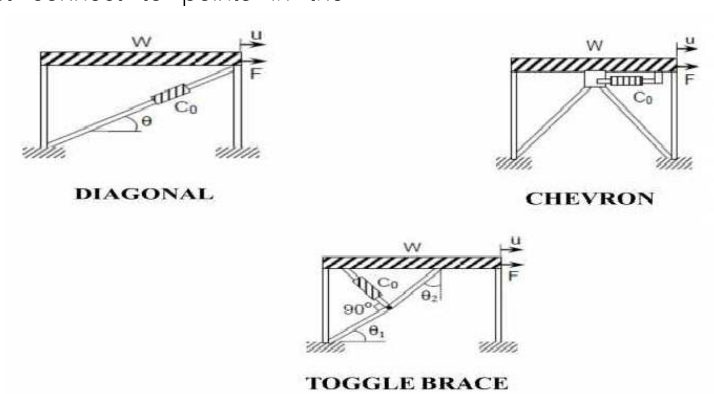


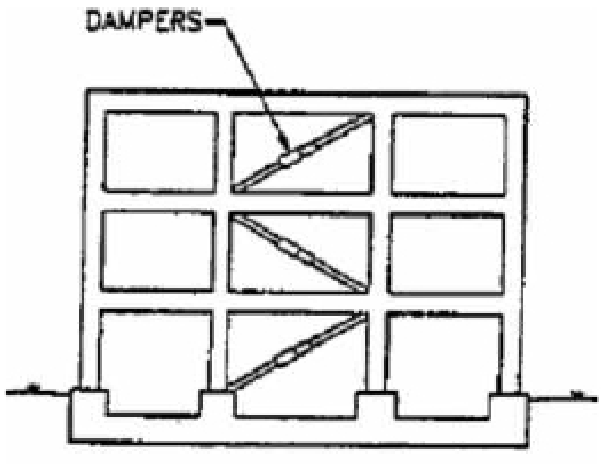
Figure 1.3 : Configurations for viscous dampers within a basic structural frame.

Figure adapted from Şigaher and Constantinou (2003)

e) Installation of FVD's

Fluid viscous dampers can be installed as diagonal members in several ways, or can tie intochevron braces. They can also be used as the two elements of the chevron braces. As show in figures 1.4 the typical fluid viscous dampers installations.

Fluid Viscous Dampers Can Be Installed In Several Ways As Shown In Following Figures



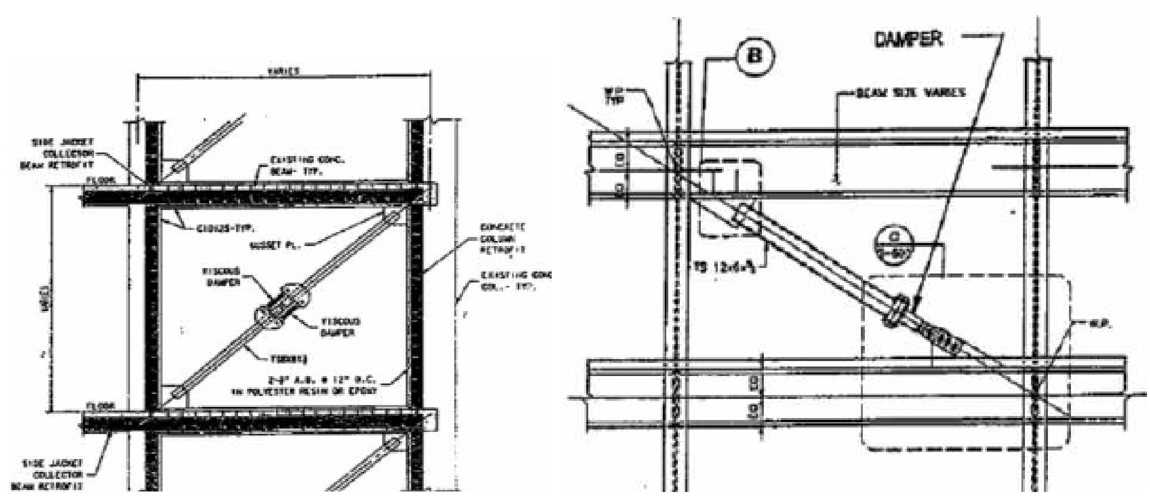


Figure 1.4 : Diagonal Bracing with Dampers

II. Review of Literature

Jinkoo K. and B. Sunghyuk [3] they investigated on appropriate plan-wise distribution of viscoelastic dampers to minimize the torsional responses of an asymmetric structure, with one axis of symmetry subjected to an earthquake-induced dynamic motion. The modal characteristic equations of a single-storey asymmetric structure with four corner columns and added viscoelastic dampers were derived, and a parametric study was performed to identify the design variables that influence the torsional responses. Based on the results of parametric study, a simple and straightforward methodology to find out the optimum eccentricity of added VED to compensate for the torsional effect of a plan-wise asymmetric structure was developed using modal coefficients. The results indicate that the torsional response of asymmetric structures can be reduced significantly following the proposed method, and that the viscoelastic dampers turn out to be more effective than viscous dampers in controlling torsional response of a plan-wise asymmetric building structure.

Diclelia, M. and A. Mehta[4] they studied of seismic performance of steel chevron braced frames (CBFs) with and without viscous fluid dampers (VFDs) as a function of the intensity and frequency characteristics of the ground motion and VFD parameters. For this purpose, comparative nonlinear time history (NLTH) analyses of single and multiple story CBFs with and without VFDs are conducted using ground motions with various frequency characteristics scaled to represent small, moderate and large intensity earthquakes. Additionally, NLTH analyses of single and multiple story CBFs with VFDs are conducted to study the effect of the damping ratio and velocity exponent of the VFD on the seismic performance of the frames. The analysis results revealed that the seismic performance of the CBFs without VFDs is very poor and sensitive to the frequency characteristics and intensity of the ground motion due to brace buckling effects. Installing VFDs into the CBFs significantly improved their seismic performance by maintaining their elastic behavior. Furthermore, VFDs with smaller velocity exponents and larger damping ratio are observed to be more effective in improving the seismic performance of the CBFs. However, VFDs with damping ratios larger than 50% do not produce significant additional improvement in the seismic performance of the CBFs.

Lap-Loi et al [5] they investigated on Optimal design theory for linear tuned mass dampers (TMD) has been thoroughly investigated, but is still under development for nonlinear TMDs. In this paper, optimization procedures in the time domain are proposed for design of a TMD with nonlinear viscous damping. A dynamic analysis of a structure implemented with a nonlinear TMD is conducted first. Optimum design parameters for the nonlinear TMD are searched using an optimization method to minimize the performance index. The feasibility of the proposed optimization method is illustrated numerically by using the Taipei 101 structure implemented with TMD. The sensitivity analysis shows that the performance index is less sensitive to the damping coefficient than to the frequency ratio. Time history analysis is conducted using the Taipei 101 structure implemented with different TMDs under wind excitation. For both linear and nonlinear TMDs, the comfort requirements for building occupants are satisfied as long as the TMD is properly designed. It was found that as the damping exponent increases, the relative displacement of the TMD decreases but the damping force increases.

Providakis, C.P [6] has studied isolation is a quite sensible structural control strategic design in reducing the response of a structural system induced by strong ground motions. It is clear that the effects of near-fault (NF) ground motions with large velocity pulses can bring the seismic isolation devices to critical working conditions. In the present paper, nonlinear time history analyses were performed using a commercial structural analysis software package to study the influence of isolation damping on base and superstructure drift. Various lead-rubber bearing (LRB) isolation systems are systematically compared and discussed for aseismic performances of two actual reinforced concrete (RC) buildings. Parametric analysis of the buildings fitted with isolation devices is carried out to choose the appropriate design parameters.

Dong-dong et al [7] studied the dynamic response analysis of damper connected adjacent multi storey structures with uncertain parameters. They considered uncertainities of mass and stiffness firstly. The ground acceleration is represented by Kanai- Tajimi filtered non-stationary process. The mean square random responses of structural displacement and storey drift are chosen as the optimization objectives. The variations of mean square responses of top floor displacements and bottom storey drifts in neighboring structures with the damper stiffness and damping coefficient are analyzed in detail. Through the parametric study, the acquiring optimum parameters of damper are regarded as numerical results. A comparative study proves that the optimal theoretical values of damper parameters are very close to those through extensive numerical parametric studies. The theory results are calculated using the first natural frequencies and the total mass of the adjacent deterministic structures with mean parameters. To mitigate the mean square random responses of displacement, acceleration and inter storey drift in adjacent structures, the performance of connecting dampers is investigated. The numerical results demonstrate that coupling adjacent structures is an effective means of protection for flexible building structures.

Huangshang and Linuo [7] carried out work to obtain the optimal parameters of dampers linking adjacent structures for seismic mitigation, two SDOF systems connected with visco-elastic damper (VED) are taken as research object and the primary structural vibration frequency ratio, connection stiffness and linking damping ratio as research parameters. Modified Kanai-Tajimi spectrum is selected to model the earthquake excitation. Finally, the seismic responses of example structures with or without connecting dampers are contrastively analyzed. The dependence of response mitigation effective on research parameters is highlighted. The results indicate fine earthquake reduction effectiveness of dampers connecting structures. It is also showed that optimal parameters of damper cannot reduce the seismic responses of the primary structures connected to the best extent simultaneously. Based on the studies they concluded that the seismic responses of both buildings could be considerably reduced if damper parameters are selected appropriately and the seismic mitigation effects are affected by the dynamic characteristics of adjacent structures are different enough. Finally the seismic reduction effect of the softer building can be more enhanced than that of the stiffer building by installing VFD's.

Sadeghi Balkanlou et al [8] investigated dampers position and optimizing their position at the height of the structure are studied. It investigates about viscous damper systems and their effects on seismic behavior of multistory structures and determines effects of damper system position on structure height using uniform distribution and SSSA methods. In this research, three 4, 8, 12storey steel structure frames were selected as the understudy models. The models were designed and analyzed based on available Codes to represent a sample of available structures. To evaluate effects of specific features of damper system, two 15% and 25% target values were considered for effective damping ratio of the damper system such that the results serve as representative of appropriate spectrum of conventional features of damper system. Following time history analyses on the models created under three earthquake records which were caled according to spectrum design of Iran 2800 Code-3rd Ed.

Raveesh R M and Sahana T S [9] investigated evaluate effect of tuned mass dampers on the structural response of multistorey RC frame structures subjected to implemental dynamic analysis. A multistorey RC frame structure buildings having a ratio of height to breadth from 1, 2 and 3 is used in this study. The models were used to represent buildings located in zone 5 of India. The systemic parameters studied are natural time period, base shear, roof displacement, lateral displacement. A single ground motions were used in the study to generate single record Time v/s Acceleration curves namely BHUJ EARTHQUAKE. These ground motions was scaled to the design spectral acceleration prior to the application. The effect of acceleration is examined in this analysis SAP 2000, a program capable of performing nonlinear dynamic analysis. Based on the analysis results, it has been concluded that the effect of tuned mass dampers plays a significant role to decrease the natural frequency, base shear, roof displacement, lateral displacement, story drift, bending moment and shear force in a multistorey RC framed Structure.

III. Modelling and Seismic Analysis

a) Modelling of the Multistorey Building

The majority of buildings in which floor diaphragms are sufficiently rigid in their planes, the dynamic analysis can be carried out by using reduced 3D model. This is based on the following assumptions:

i. The floors are rigid in their planes having 3 DOF's, to horizontal translations and a single rotation about a vertical axis.
ii. The mass of building and mass moment of inertia are lumped at the floor levels at the corresponding degrees of freedom.
iii. The inertia forces or movements due to vertical or rotational components of joint motions are negligible, therefore ignored.

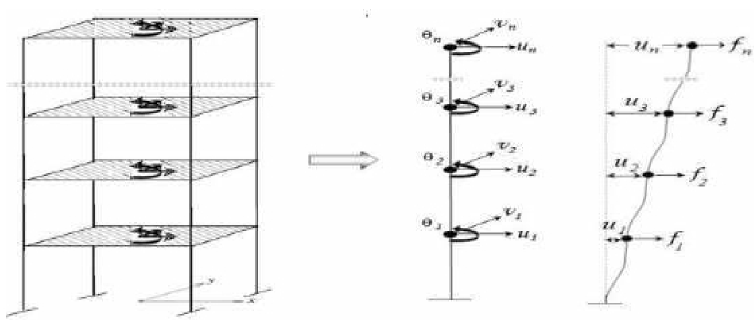


Fig. 3.1 : Building Model with 3DOFs

The simplified model with above assumptions is shown in Fig. 3.1. The dynamic degrees of freedom are drastically reduced by static condensation and yet it produces quite accurate results. In case, the floor diaphragms are not adequately rigid in buildings with very stiff vertically resisting elements such as elevator cores, and diaphragms having large openings, irregular shapes etc., the in-plane rigid assumption is not valid. In such cases, a more complex model with additional degrees of freedom is considered to properly represent in-plane flexibility. The floor slabs in such cases can be idealized as an assemblage of finite elements.

b) Analysis Using Sap 2000

The entire analysis has done for all the 3D models using SAP 2000 nonlinear version software. The results will be tabulated in order to focus the parameters such as time period, base shear, story drift and lateral displacements in linear analysis.

c) Response Spectrum Method

Dynamic analysis of the building models is performed using SAP 2000. The lateral loads generated by ETABS correspond to the seismic zone V and 5% damped response spectrum given in IS 1893 (Part 1): 2002. The fundamental natural period values are calculated by SAP 2000, by solving the Eigen value problem of the model. Thus, the total earthquake load generated and its distribution along the height corresponds to the mass and stiffness distribution as modeled by SAP 2000. Here, as in the equivalent static analysis, the seismic mass is calculated using full dead load plus 25% of live load. The 5% damped response spectrum is considered for all modes of the building. For the modal combination the square root of sum of squares (SRSS) method is considered, because in this method of modal combination coupling of the modes doesn't take place. For each displacement and force in the structure, the modal combinations produce a single positive results for each direction of acceleration, these directional value for a given response quantity have to be combined to produce a single positive result, and for this directional combination, CQC method is adopted. After defining the response spectrum case, analysis is carried out.

d) Pushover Analysis

After the linear static analysis the designing of 3D Building model for gravity load combinations as per IS 456-2000 has done. Later assign the default hinge properties available in SAP 2000 Nonlinear as per ATC-40 to the frame elements. For the beam default hinge that yields based upon the flexure (M3) is assigned, for the column default hinge that yields based upon the interaction of the axial force and bending moment (P M2 M3) is assigned.

Define three static pushover cases. 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.

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 results in order to obtain the inelastic behavior.

The effective stiffness of friction damper is (0.2 to 1.2 times the initial stiffness (ki) of the frame structures) and damping coefficient. Initial elastic stiffness of modelled frame structures is determined from non-linear static analysis (Pushover curve) and damping ratio is a function of structure mass, stiffness and damping ratio. In the present study damping ratio is taken as 5% of the critical value and mass of the frame structure is computed by using total gravity dead loads.

Where,

Damping Coefficient=ξ x 2√

ξ = Damping ratio Ki = Initial stiffness.

e) Details of Selected Building

In the present study reinforced concrete moment resisting frame building of G+20 are considered. The plan layout, elevations and 3D view of all storeyed buildings with and without dampers are as shown in the below Figures. The building is considered to be located in the seismic zone v and intended for commercial purpose.

Model-I Building without dampers.

Model-II –Building with dampers.

The building of G+20 has been modeled by providing with and without damper providing all parameters using SAP 2000 software. The building considered to model as shown in following figures.

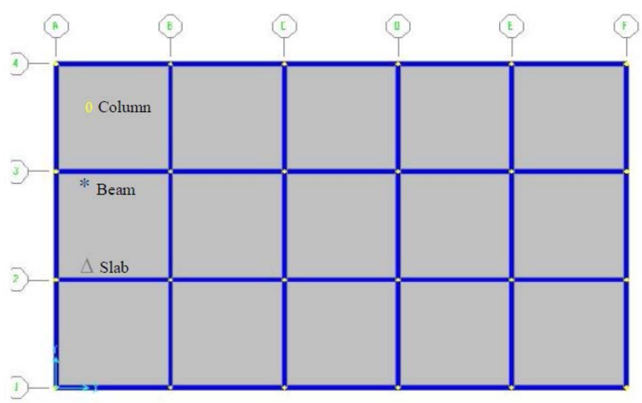


Fig. 3.2 : Plan of Selected Multistorey Building Model

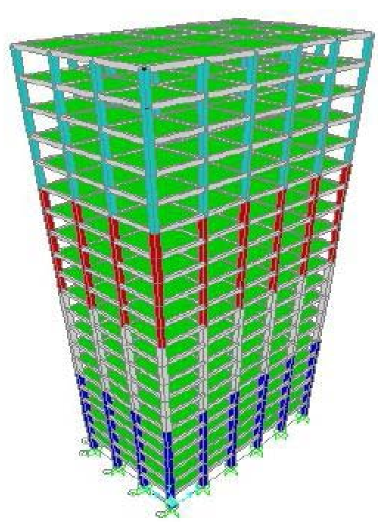


Fig. 3.3 : Model G+20 without FVD

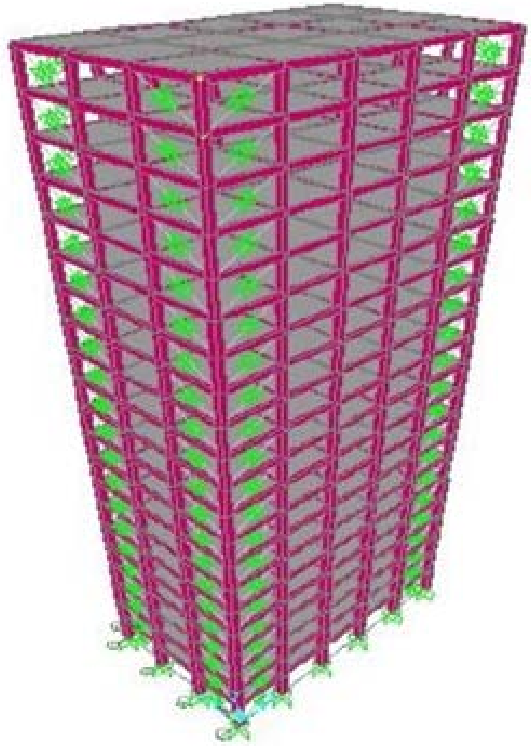


Fig. 3.4 : Model G+20 with FVD

The analysis has been carried out by Equivalent Static Method and Response Spectrum Method.The results of Time period, Lateral displacement, Base shear, Storey drift were determined for all models.

f) Load Combinations

The following load combinations are considered for the analysis and design as per IS: 1893-2002.

Table 3.1: Load combinations as per IS: 1893-2002 and IS: 875 (Part3)-1987

LoadCombination	LoadFactors
Gravityanalysis	1.5(DL+LL)
Equivalentstaticanalysis	1.2(DL+LL±EQX) 1.2(DL+LL±EQY) 1.5(DL±EQX) 1.5(DL±EQY) 0.9(DL±EQX) 0.9(DL±EQY)
Responsespectrum analysis	1.2(DL+LL±RSX) 1.2(DL+LL±RSY) 1.5(DL±RSX) 1.5(DL±RSY) 0.9(DL±RSX) 0.9(DL±RSY)

The example of buildings considered in the present study is appropriately modeled in SAP 2000 by giving all the required input data mentioned in the APPENDIX A. The building models are analyzed separately as per the analysis methods mentioned in Table 3.1 with respect to the load combinations

IV. Results and Discussions

a) Natural Time Periods

The natural time periods obtained from seismic code IS 1893 (Part 1) -2000 and analytical results obtained using (SAP 2000) are given in Table 4.1 and Fig.4.1.

Table 4.1 : Codal and Analytical Time Period (seconds) for all storey building as per IS 1893 (Part I) – 2000

BUILDING	MODELS	GRAVITYANALYSIS	
		CODAL	1.5(DL+IL)
G+20	ModelI	1.8150	3.5177
	ModelII	1.8150	1.9832

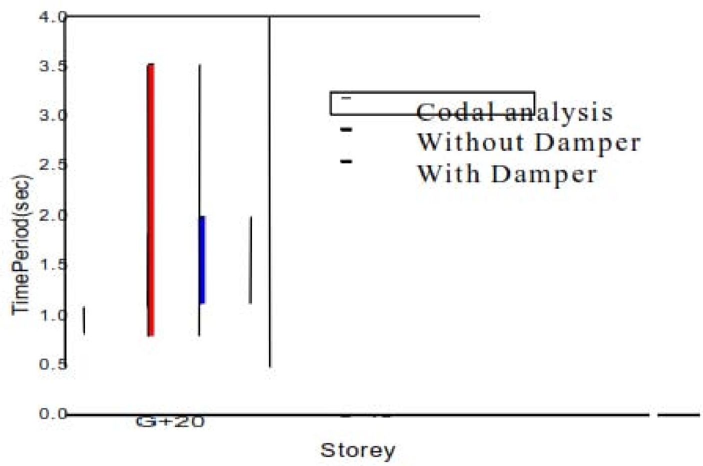


Fig.4.1 : Natural time period (seconds) profile for all Storey buildings for codal and analytical load combination as per IS1893 (Part 1) -2000.

(i) Model-I: Building without damper.
(ii) Model-II: Building with damper.

The fundamental natural periods obtained for the seismic designed building and gravity models have plotted in Fig. 4.1 From the plot it is very clear that, stiffness of the building is directly proportional to its natural frequency and hence inversely proportional to the natural period. That is, if the stiffness of building is increased the natural period goes on decreasing. And as the natural frequency of the taller buildings is high due to the more mass, the natural period goes on increasing for three different multi storied buildings. The comparison of natural period presented in the table or plot 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 period on the basis of mass and stiffness of the building (Eigen value and Eigen vectors).

b) Base Shear

In the response spectrum method the design base shear (VB) is made equal to the base shear obtained from equivalent static method V B as per clause 7.8.2 of IS: 1893(Part 1):2002 by applying the scaling factors calculated as shown in Table 4.2 to 4.4.

The base shear is a function of mass, stiffness, height, and the natural period of the building structure. From the previous results it is very clear that the fundamental natural periods obtained from the code, fall far short from that of the analytical natural periods. And in the equivalent static method design horizontal acceleration value obtained by codal natural period is adopted, and the basic assumption in the equivalent static method is that only first mode of vibration of building governs the dynamics and the effect of higher modes are not significant therefore, higher modes are not considered in this method. Hence base shears obtained from the equivalent static method are larger than the dynamic response spectrum method where in the dynamic response spectrum, all the modes of the building are considered, and first mode governs in the shorter buildings and as the storey increases for tall buildings, the flexibility increases and higher modes come into picture. The base shear for the equivalent static method (VB) and the response spectrum method (V B) as per IS 1893 (Part 1): 2002 for the various building models are listed in the tables below.

Table 4.2 : Base shear and scaling factors for all models for 1.2(DL+LL+EQL) Combination

Storey	Base shear in kN for Model-I						Baseshear in kN for Model–II					
	EQX	RSX	Scale Factor	EQY	RSY	Scale Factor	EQX	RSX	Scale Factor	EQY	RSY	Scale Factor
G+20	7957.35	4408.74	1.8049	7995.65	4284.22	1.8663	8804.51	6073.75	1.4496	8827.41	5955.21	1.4823

Table 4.3 : Base shear and scaling factors for all models for 1.5(DL+EQL) combination

Storey	Base shear inkN for Model-I						Base shear in kN forModel-II					
	EQX	RSX	Scale Factor	EQY	RSY	Scale Factor	EQX	RSX	Scale Factor	EQY	RSY	Scale Factor
G+20	9946.69	5268.54	1.8879	9946.69	5201.59	1.9122	11005.69	755.89	1.4558	11005.69	6974.89	1.5779

Table 4.4 : Base shear and scaling factors for all models for 0.9(DL+EQL) combination

Storey	Base shear in kN for Model-I						Base shear in kN for Model–II					
	EQX	RSX	Scale Factor	EQY	RSY	Scale Factor	EQX	RSX	Scale Factor	EQY	RSY	Scale Factor
G+20	9946.69	5268.54	1.8879	9946.69	5201.59	1.9122	11005.69	7559.89	1.4558	11005.69	6974.89	1.5779

(i) Model – I: Building without Damper.

(ii) Model – II: Building with Damper.

The base shear is a function of mass, stiffness, height, and the natural period of the building structure. Moreover the basic assumption in the equivalent static method is that only first mode of vibration of building governs the dynamics of the structures. In dynamic response spectrum method, all the modes of the building are considered, and the first mode governs in the case of shorter buildings and as the number of storeys increase for tall buildings, the flexibility increases and higher modes come into picture. Hence base shears obtained from the equivalent static method are larger than the base shear obtained from dynamic response spectrum method. The base shear values obtained by equivalent static method are higher than those obtained by Response spectrum method for gravity and seismic analysis for G+20 buildings.

c) Lateral Displacement

The lateral displacements obtained for equivalent static method (EQS) and response spectrum method (RSP) for 11 to 21 storey building models, along both X and Y directions are listed in the tables below. In order to account the effect of torsion the displacements are captured in both directions when force is acting in particular direction. Table 4.5 shows the lateral displacements of G+20 storied building with and without damper, by taking load combinations in consideration. Similarly fig.4.2 to 4.7 indicates the plot of lateral displacements versus storey number for various load combinations.

Table 4.5 : Lateral displacement of G+20 storey building models for seismic analysis

(a)Longitudinal direction for seismic combination1.2(DL+LL+EQX)and1.2(DL+LL+RSX)				
STOREY	Equivalent static method		Respon sespectrum method	
	Lateral displace ment(mm)		Lateral displacement(mm)	
	ModelI	ModelII	ModelI	ModelII
21	345.68	149.53	239.11	91.04
20	340.87	146.98	236.24	89.67
19	333.40	143.29	231.81	87.69
18	323.26	138.48	225.87	85.14
17	310.64	132.64	218.54	82.07
16	295.73	125.87	209.86	78.52
15	280.29	118.97	200.79	74.90
14	263.41	111.51	190.76	70.94
13	245.20	103.51	179.75	66.64
12	225.81	95.06	167.78	62.02
11	205.41	86.23	154.84	57.08
10	185.20	77.60	141.69	52.14
9	164.44	68.80	127.84	46.99
8	143.24	59.86	113.28	41.61
7	121.71	50.82	98.01	35.99
6	100.05	41.77	82.03	30.15
5	79.04	33.08	65.92	24.31
4	58.38	24.55	49.51	18.37
3	38.56	16.34	33.21	12.42
2	20.57	8.81	17.94	6.79
1	6.37	2.76	5.61	2.15
BASE	0.00	0.00	0.00	0.00

(b)Transverse direction for seismic combination1.2(DL+LL+EQY)and1.2(DL+LL+RSY)				
STOREY	Equivalen tstatic method		Responsespectrummethod	
	Lateral displacement(mm)		Lateraldisplacement(mm)	
	ModelI	ModelII	ModelI	ModelII
2	396.39	166.85	221.18	97.85
2	389.73	163.47	217.82	96.02
1	380.34	158.96	213.21	93.63
1	368.04	153.28	207.26	90.67
1	353.04	146.51	200.10	87.19
1	335.58	138.77	191.78	83.23

1	317.41	130.87	183.05	79.18
1	297.73	122.39	173.53	74.81
1	276.62	113.37	163.17	70.12
1	254.27	103.89	151.99	65.11
1	230.87	94.03	140.00	59.79
1	207.64	84.41	127.79	54.48
9	183.90	74.62	115.02	48.97
8	159.73	64.72	101.66	43.24
7	135.30	54.78	87.72	37.30
6	110.85	44.85	73.21	31.14
5	87.19	35.37	58.60	25.01
4	64.06	26.11	43.81	18.80
3	42.04	17.27	29.22	12.65
2	22.24	9.25	15.67	6.87
1	6.8	2.89	4.85	2.17
BASE	0.0	0.00	0.00	0.00

(c)Longitudinal direction for seismic combination1.5(DL+EQX)and1.5(DL+RSX)				
STOREY	Equivalent static method		Response spectrum method	
	Lateral displace ment (mm)		Lateral displace ment(mm)	
	ModelI	ModelII	ModelI	ModelII
21	432.06	186.06	298.85	112.96
20	426.03	182.87	295.24	111.23
19	416.69	178.25	289.70	108.74
18	404.02	172.24	282.29	105.56
17	388.26	164.96	273.13	101.75
16	369.63	156.52	262.29	97.33
15	350.32	147.91	250.95	92.82
14	329.23	138.62	238.41	87.91
13	306.47	128.66	224.66	82.58
12	282.24	118.14	209.70	76.84
11	256.74	107.16	193.54	70.72
10	231.48	96.42	177.10	64.60
9	205.54	85.47	159.79	58.21
8	179.03	74.35	141.59	51.54
7	152.13	63.12	122.51	44.58
6	125.05	51.88	102.54	37.35
5	98.79	41.07	82.40	30.11
4	72.97	30.48	61.89	22.75

3	48.20	20.28	41.51	15.39
2	25.71	10.94	22.42	8.41
1	7.96	3.42	7.01	2.66
BASE	0.00	0.00	0.00	0.00

(d)Transverse direction for seismi ccombination1.5(DL+EQY)and1.5(DL+RSY)				
STOREY	Equivalent static method		Response spectrum method	
	Lateral displacement(mm)		Lateral displacement(mm)	
	ModelI	ModelII	ModelI	ModelII
21	495.35	207.57	276.34	121.31
20	487.05	203.36	272.16	119.04
19	475.32	197.72	266.41	116.05
18	459.95	190.63	258.98	112.36
17	441.21	182.19	250.04	108.03
16	419.39	172.53	239.64	103.11
15	396.70	162.69	228.75	98.08
14	372.10	152.13	216.85	92.66
13	345.73	140.90	203.91	86.84
12	317.80	129.11	189.95	80.63
11	288.55	116.83	174.97	74.03
10	259.53	104.87	159.71	67.46
9	229.85	92.70	143.75	60.63
8	199.64	80.39	127.06	53.54
7	169.11	68.03	109.63	46.18
6	138.55	55.70	91.50	38.55
5	108.98	43.92	73.25	30.97
4	80.07	32.42	54.76	23.28
3	52.54	21.44	36.52	15.66
2	27.80	11.49	19.59	8.51
1	8.51	3.60	6.06	2.69
BASE	0.00	0.00	0.00	0.00

(e)Longitudinal direction forseismic combination0.9(DL+EQX)and0.9(DL+RSX)				
STOREY	Equivalent static method		Responsespectrummethod	
	Lateral displace ment(mm)		Lateral displace ment(mm)	
	ModelI	ModelII	ModelI	ModelII
21	432.08	185.58	298.87	112.48
20	426.02	182.38	295.24	110.75
19	416.69	177.77	289.70	108.27
18	404.02	171.77	282.29	105.10
17	388.25	164.51	273.13	101.29
16	369.63	156.08	262.29	96.90
15	350.32	147.49	250.95	92.41
14	329.23	138.22	238.41	87.51
13	306.47	128.29	224.66	82.20
12	282.24	117.79	209.70	76.49
11	256.74	106.84	193.54	70.40
10	231.48	96.12	177.09	64.30
9	205.54	85.20	159.79	57.94
8	179.03	74.11	141.59	51.30
7	152.13	62.91	122.50	44.38
6	125.05	51.70	102.54	37.17
5	98.79	40.93	82.	29.97
4	72.97	30.37	61.	22.64
3	48.20	20.21	41.	15.32
2	25.71	10.90	22.	8.37
1	7.96	3.41	7.	2.65
BASE	0.00	0.00	0.00	0.00

(f)transverse direction for seismic combination0.9(DL+EQY)and0.9(DL+RSY)				
STOREY	Equivalentstaticmethod		Response spectrum method	
	Lateral displace ment(mm)		Lateral displace ment(mm)	
	ModelI	ModelII	ModelI	ModelII
21	495.33	207.03	276.33	120.78
20	487.05	202.83	272.16	118.51
19	475.31	197.20	266.41	115.53
18	459.95	190.12	258.98	111.85
17	441.21	181.70	250.04	107.54
16	419.39	172.05	239.64	102.63
15	396.70	162.24	228.75	97.63

14	372.11	151.70	216.85	92.23
13	345.73	140.49	203.91	86.43
12	317.80	128.72	189.95	80.25
11	288.55	116.48	174.97	73.68
10	259.53	104.55	159.71	67.14
9	229.85	92.41	143.75	60.34
8	199.64	80.13	127.06	53.28
7	169.11	67.80	109.63	45.96
6	138.55	55.51	91.50	38.36
5	108.98	43.77	73.25	30.82
4	80.07	32.30	54.76	23.17
3	52.54	21.36	36.52	15.58
2	27.80	11.45	19.59	8.47
1	8.51	3.59	6.06	2.68
BASE	0.00	0.00	0.00	0.00

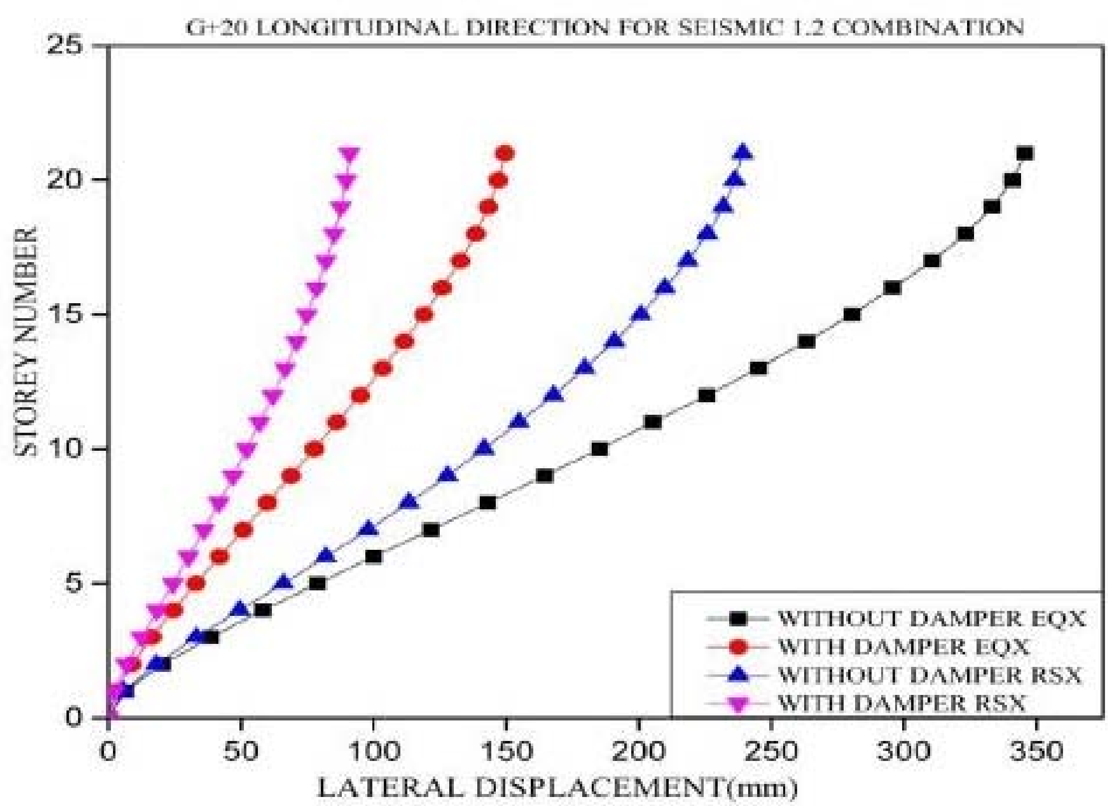


Fig. 4.2 : Lateral displacement (mm) profile for G+20 storey in Longitudinal direction By Seismic 1.2 EQX and RSX

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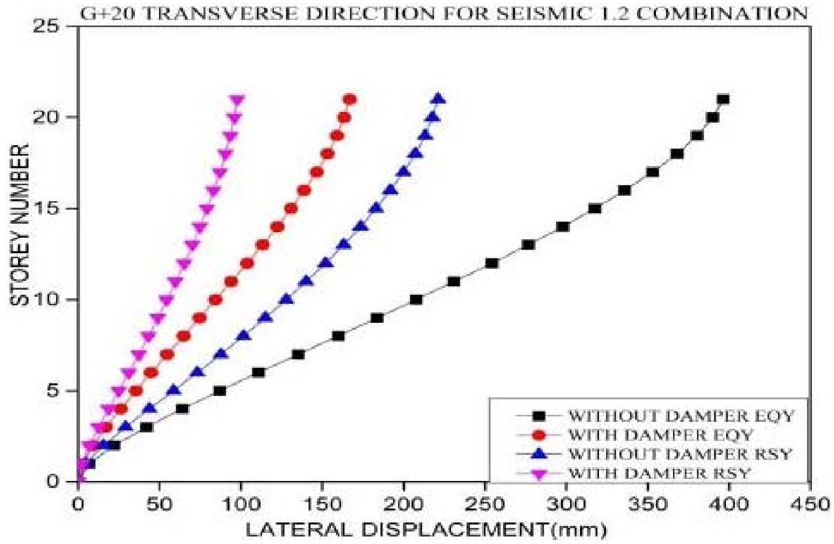

Fig.4.3 : Lateral displacement (mm) profile for G+20 storey in Transverse direction by Seismic 1.2 EQX and RSY

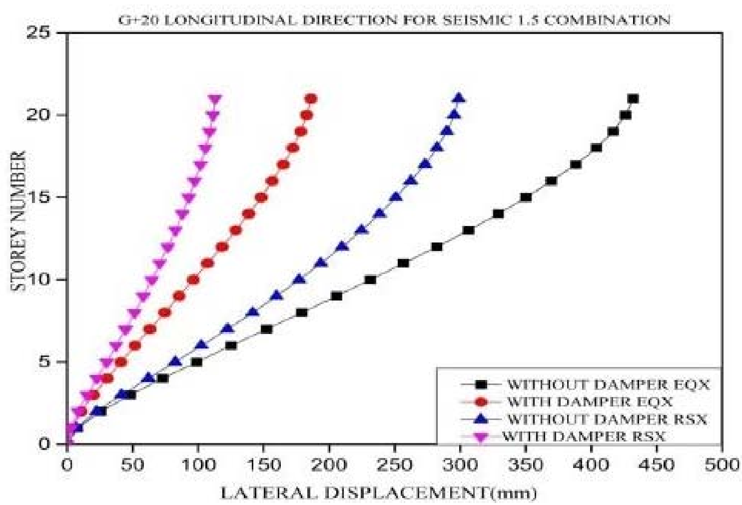

Fig. 4.4 : Lateral displacement (m) profile for G+20 storey in longitudinal direction by Seismic 1.5 EQX and RSX

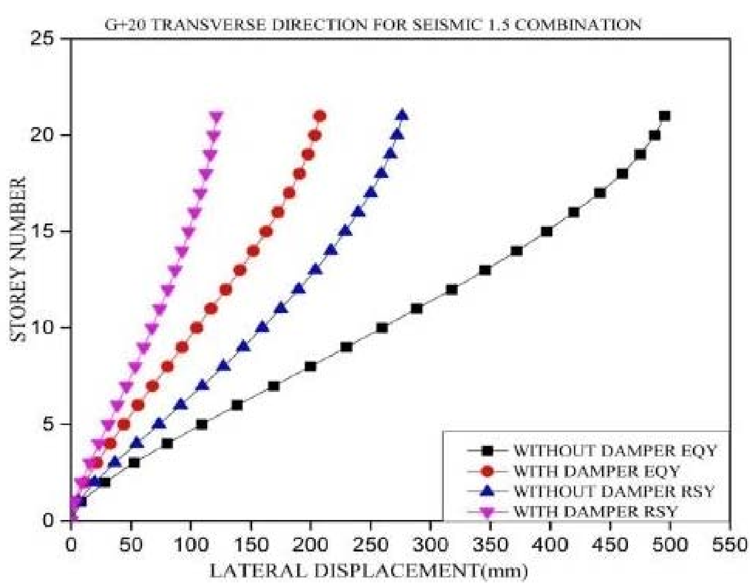

Fig.4.5 : Lateral displacement (mm) profile for G+20 storey in Transverse direction by Seismic 1.5 EQY and RSY

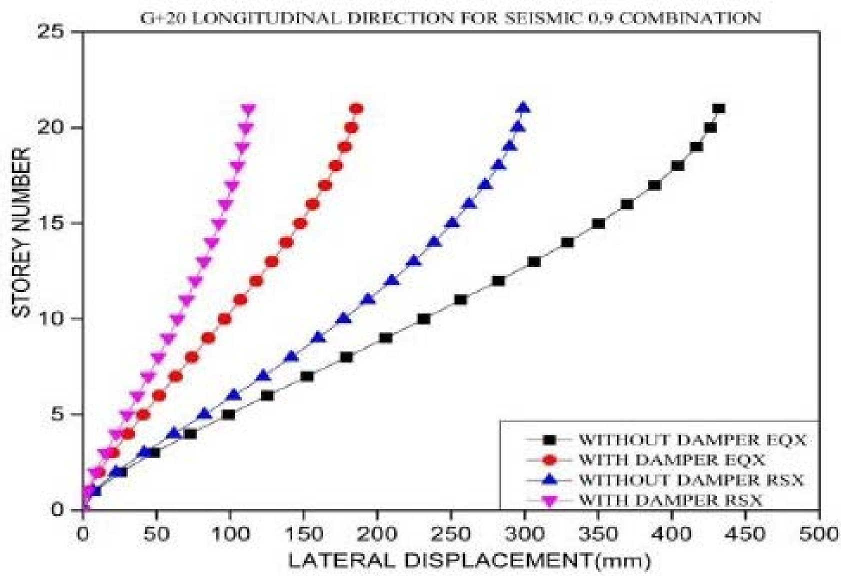

Fig.4.6 : Lateral displacement (mm) profile for G+20 storey in Longitudinal direction by Seismic 0.9 EQX and RSX

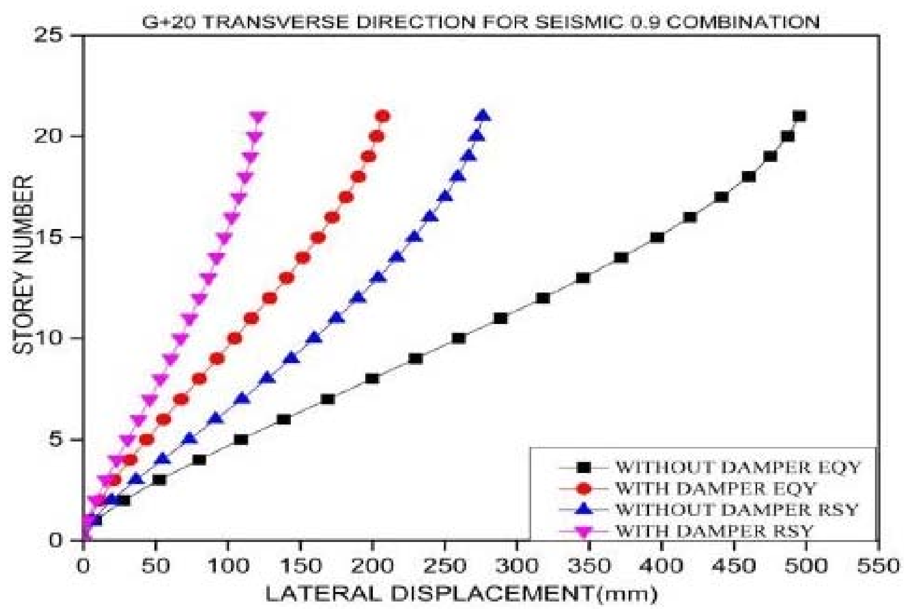

Fig.4.7: Lateral displacement (mm) profile for G+20 storey in Transverse direction by Seismic 0.9 EQY and RSY

For all the load combination the lateral displacement is maximum at roof level has a maximum value of 432.06mm for model I compared to model II maximum value of 186.06mm in longitudinal direction for equivalent static method. And in response spectrum method model I and model II have displaced maximum values of 298.85mm and 112.96mm respectively in longitudinal direction. Similarly, in transverse direction model I has displaced 495.35mm and model II 207.57mm for equivalent static method, in response spectrum method model I and model II have displaced 276.34mm and 121.31mm respectively.

This clearly shows that the fluid viscous damper are effective reducing the lateral displacement due to seismic loads.

From the results of roof displacement for Model I (bare frame without FVD) and Model II (building with FVD) it can be observed that Model I gives maximum displacement for G+20 storey buildings analysed for seismic loads which gives maximum displacement for Model I. Lateral displacements increases as the number of stories increases. So the lateral displacement can be reduced by introduction of FVD in building.

d) Storey Drifts

Inter Storey drifts for different models obtained from the analysis are shown in Table.4.6 below. Inter Storey drifts profile can also be observed in Fig. 4.8 to 4.13.

According to IS 1893(Part 1):2002 clause 7.11.1 Storey drifts limitations are explained that the Storey drifts in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times the storey height. For 3.5 m storey height has got 14.00 mm.

Table 4.6 : Inter storey drift of G+20 storey building models for seismic analysis

(a)Longitudinal direction for seismic combination1.2(DL+LL+EQX)and1.2(DL+LL+RSX)				
STOREY	Equivalent static method		Responsespectrummethod	
	Inter Storey Drift(mm)		Inter Storey Drift(mm)	
	ModelI	ModelII	ModelI	ModelII
21	1.37	0.73	0.82	0.39
20	2.14	1.06	1.27	0.57
19	2.90	1.37	1.70	0.73
18	3.60	1.67	2.09	0.87
17	4.26	1.94	2.48	1.01
16	4.41	1.97	2.59	1.04
15	4.82	2.13	2.87	1.13
14	5.20	2.28	3.15	1.23
13	5.54	2.41	3.42	1.32
12	5.83	2.52	3.70	1.41
11	5.77	2.47	3.76	1.41
10	5.93	2.51	3.96	1.47
9	6.06	2.56	4.16	1.54
8	6.15	2.58	4.36	1.60
7	6.19	2.59	4.57	1.67
6	6.00	2.48	4.60	1.67
5	5.90	2.44	4.69	1.70
4	5.66	2.35	4.66	1.70
3	5.14	2.15	4.36	1.61
2	4.06	1.73	3.52	1.33
1	1.82	0.79	1.60	0.61
BASE	0.00	0.00	0.00	0.00

(b)Transverse direction for seismic combination1.2(DL+LL+EQY)and1.2(DL+LL+RSY)				
STOREY	Equivalent static method		Respon sespectrum method	
	Inter Storey Drift(mm)		Inter Storey Drift(mm)	
	ModelI	ModelII	ModelI	ModelII
21	1.90	0.96	0.96	0.52
20	2.68	1.29	1.32	0.68
19	3.51	1.62	1.70	0.85
18	4.28	1.93	2.05	0.99
17	4.99	2.21	2.38	1.13
16	5.19	2.26	2.49	1.16
15	5.62	2.42	2.72	1.25
14	6.03	2.58	2.96	1.34
13	6.39	2.71	3.19	1.43
12	6.68	2.82	3.42	1.52
11	6.64	2.75	3.49	1.52
10	6.78	2.80	3.65	1.57
9	6.91	2.83	3.82	1.64
8	6.98	2.84	3.98	1.70
7	6.98	2.84	4.15	1.76
6	6.76	2.71	4.17	1.75
5	6.61	2.65	4.23	1.77
4	6.29	2.53	4.17	1.76
3	5.66	2.29	3.87	1.65
2	4.41	1.82	3.09	1.34
1	1.94	0.83	1.38	0.62
BASE	0.00	0.00	0.00	0.00

(c)Longitudinal direction for seismic combination1.5(DL+EQX)and1.5(DL+RSX)				
STOREY	Equivalent static method		Respon sespectrum method	
	Inter Storey Drift (mm)		Inter Storey Drift (mm)	
	ModelI	ModelII	ModelI	ModelII
21	1.72	0.91	1.03	0.49
20	2.67	1.32	1.58	0.71
19	3.62	1.72	2.12	0.91
18	4.50	2.08	2.62	1.09
17	5.32	2.41	3.10	1.26

16	5.52	2.46	3.24	1.29
15	6.03	2.66	3.58	1.40
14	6.50	2.84	3.93	1.52
13	6.92	3.01	4.27	1.64
12	7.29	3.14	4.62	1.75
11	7.22	3.07	4.70	1.75
10	7.41	3.13	4.94	1.82
9	7.57	3.18	5.20	1.91
8	7.69	3.21	5.45	1.99
7	7.74	3.21	5.71	2.07
6	7.50	3.09	5.75	2.07
5	7.38	3.03	5.86	2.10
4	7.08	2.91	5.82	2.10
3	6.43	2.67	5.45	1.99
2	5.07	2.15	4.40	1.64
1	2.27	0.98	2.00	0.76
BASE	0.00	0.00	0.00	0.00

(d)Transverse direction for seismic combination1.5(DL+EQY)and1.5(DL+RSY)				
STOREY	Equivalent static method		Responsespectrummethod	
	Inter Storey Drift (mm)		Inter Storey Drift (mm)	
	ModelI	ModelII	ModelI	ModelII
21	2.37	1.20	1.19	0.65
20	3.35	1.61	1.64	0.85
19	4.39	2.03	2.12	1.06
18	5.35	2.41	2.56	1.24
17	6.23	2.76	2.97	1.41
16	6.48	2.81	3.11	1.44
15	7.03	3.02	3.40	1.55
14	7.54	3.21	3.70	1.66
13	7.98	3.37	3.99	1.77
12	8.35	3.51	4.28	1.88
11	8.29	3.42	4.36	1.88
10	8.48	3.48	4.56	1.95
9	8.63	3.52	4.77	2.03
8	8.72	3.53	4.98	2.10
7	8.73	3.52	5.18	2.18
6	8.45	3.36	5.21	2.17

5	8.26	3.29	5.28	2.20
4	7.86	3.14	5.21	2.18
3	7.07	2.84	4.84	2.04
2	5.51	2.25	3.86	1.66
1	2.43	1.03	1.73	0.77
BASE	0.00	0.00	0.00	0.00

(e)Longitudinal direction for seismic combination0.9(DL+EQX)and0.9(DL+RSX)				
STOREY	Equivalen tstatic method		Responsespectrummethod	
	Inter Storey Drift (mm)		Inter Storey Drift (mm)	
	ModelI	ModelII	ModelI	ModelII
21	1.73	0.91	1.04	0.50
20	2.67	1.32	1.58	0.71
19	3.62	1.71	2.12	0.91
18	4.51	2.08	2.62	1.09
17	5.32	2.41	3.10	1.26
16	5.52	2.45	3.24	1.28
15	6.03	2.65	3.58	1.40
14	6.50	2.84	3.93	1.52
13	6.92	3.00	4.27	1.63
12	7.28	3.13	4.62	1.74
11	7.22	3.06	4.70	1.74
10	7.41	3.12	4.94	1.82
9	7.57	3.17	5.20	1.90
8	7.69	3.20	5.45	1.98
7	7.73	3.20	5.71	2.06
6	7.50	3.08	5.75	2.06
5	7.38	3.02	5.86	2.09
4	7.08	2.90	5.82	2.09
3	6.43	2.66	5.45	1.98
2	5.07	2.14	4.40	1.64
1	2.27	0.97	2.00	0.76
BASE	0.00	0.00	0.00	0.00

(f)transverse direction for seismic combination0.9(DL+EQY)and0.9(DL+RSY)				
STOREY	Equivalent static method		Response spectrum method	
	Inter Storey Drift(mm)		Inter Storey Drift(mm)	
	ModelI	ModelII	ModelI	ModelII
21	2.37	1.20	1.19	0.65
20	3.35	1.61	1.65	0.85
19	4.39	2.02	2.12	1.05
18	5.35	2.41	2.56	1.23
17	6.24	2.76	2.97	1.40
16	6.48	2.80	3.11	1.43
15	7.03	3.01	3.40	1.54
14	7.54	3.20	3.70	1.66
13	7.98	3.36	3.99	1.77
12	8.36	3.50	4.28	1.88
11	8.29	3.41	4.36	1.87
10	8.48	3.47	4.56	1.94
9	8.63	3.51	4.77	2.02
8	8.72	3.52	4.98	2.09
7	8.73	3.51	5.18	2.17
6	8.45	3.35	5.21	2.15
5	8.26	3.28	5.28	2.19
4	7.86	3.13	5.21	2.17
3	7.07	2.83	4.84	2.03
2	5.51	2.25	3.86	1.65
1	2.43	1.02	1.73	0.77
BASE	0.00	0.00	0.00	0.00

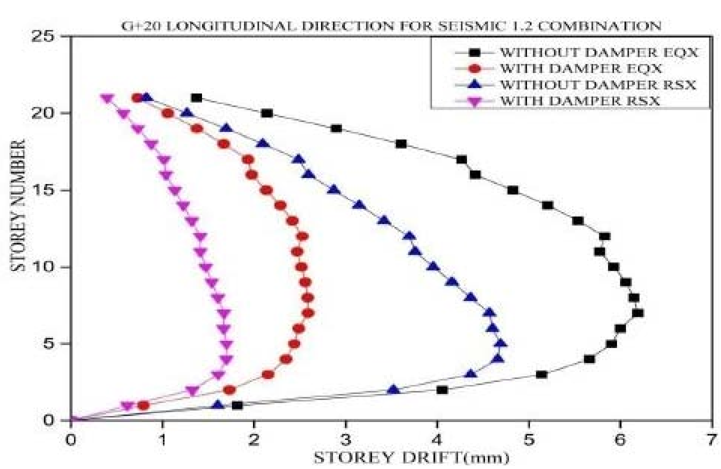

Fig.4.8 : Storey drifts profile for G+20 storey in longitudinal direction by Seismic 1.2 EQX and RSX

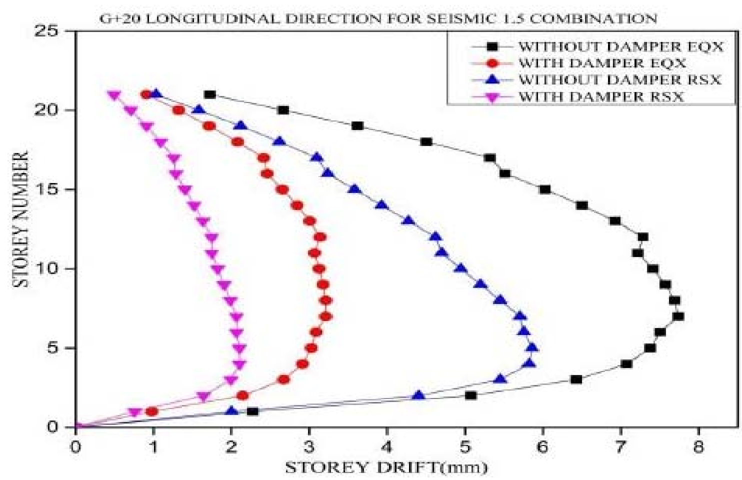

Fig. 4.9 : Storey drifts profile for G+20 storey in longitudinal direction by Seismic 1.5EQX and RSX

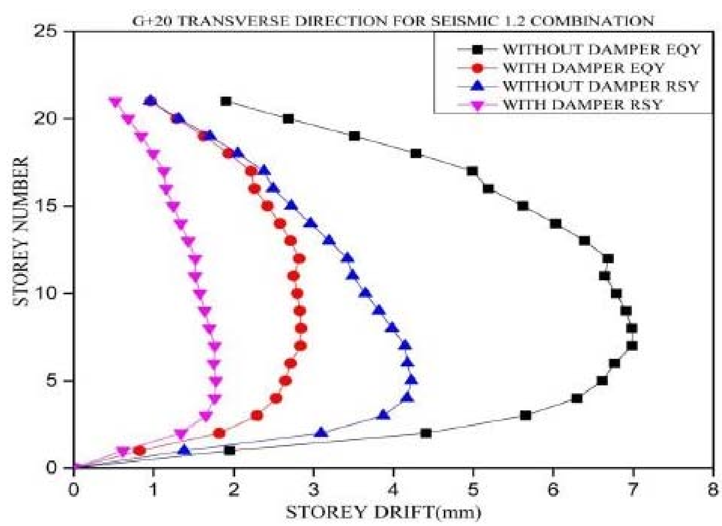

Fig. 4.10 : Storey drifts profile for G+20 storey in transverse direction by Seismic 1.2 EQY and RSY

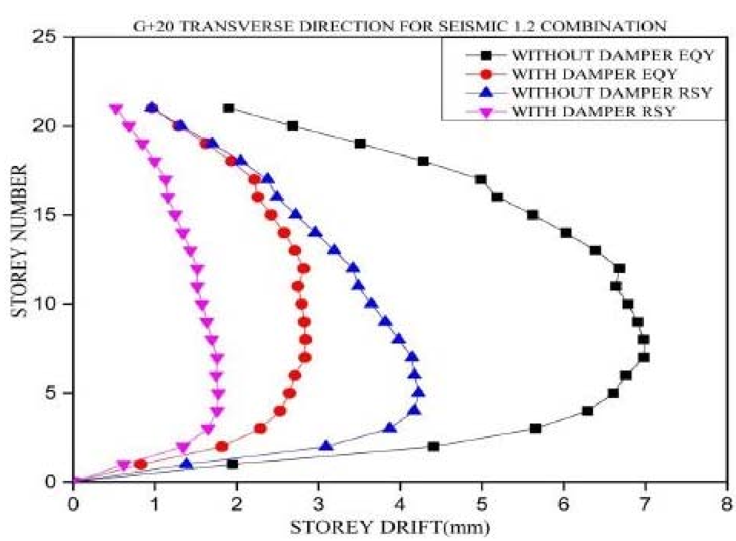

Fig. 4.11 : Storey drifts profile for G+20 storey in transverse direction by Seismic 1.5 EQY and RSY

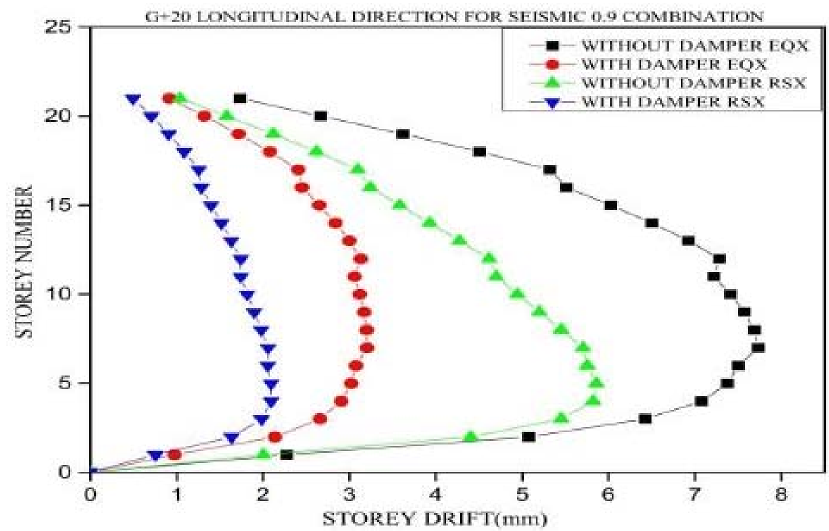

Fig. 4.12 : Storey drifts profile for G+20 storey in longitudinal direction by Seismic 0.9 EQX and RSX

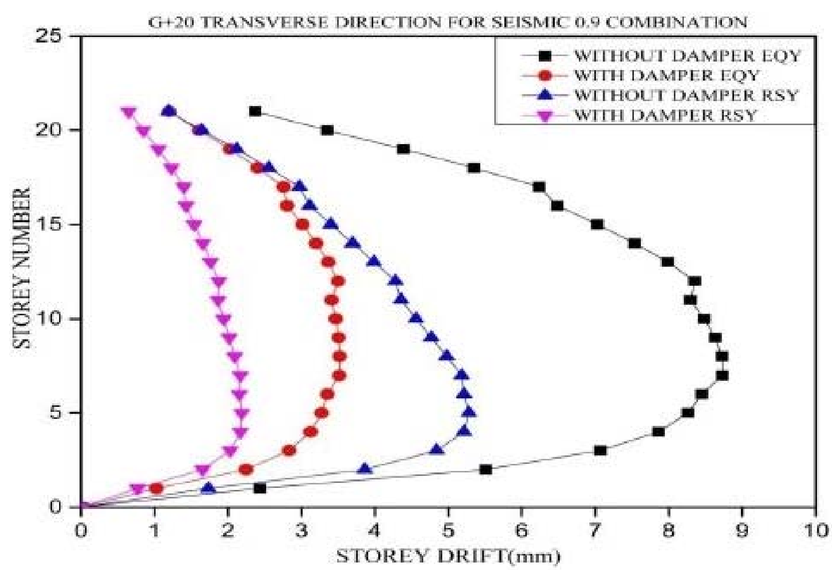

Fig. 4.13 : Storey drifts profile for G+20 storey in transverse direction by Seismic 0.9 and RSY

(i) Model-I: Building without FVD
(ii) Model-II: Building with FVD

For all the load combination the storey drift is maximum for model I compared to model II the model I has a maximum value of 7.74mm for model I compared to model II maximum value of 3.21mm in longitudinal direction for equivalent static method. And in response spectrum method model I and model II have drifted maximum values of 5.86mm and 2.10mm respectively in longitudinal direction. Similarly in transverse direction model I has drifted 8.73mm and model II 3.52mm for equivalent static method, in response spectrum method model I and model II have drifted 5.28mm and 2.20mm respectively.

This clearly shows that the fluid viscous dampers are effective reducing the storey drift due to seismic loads.

As per Clause 7.11.1 of IS 1893 (Part 1)2002 the inter storey drift in any storey should not exceed 0.004 times the storey height. From the results mentioned above it can be observed that Model I, Model II doesn't crosses inter storey drift limits for equivalent static method and also Response spectrum method none of the buildings has crossed the drift limits in any direction for G+20 storey models.

From above results for Model I i.e. regular building has got more Storey drifts for G+20 and for Model II (building with fluid viscous dampers) has less storey drift compared to Model-I. The inter storey drift is more at the bottom storey than at the top storey and also as the number of storey increases the relative drift of the storey also increase. The introduction of fluid viscous dampers in the building drastically reduces the inter storey drift in the building.

V. Conclusions

The Present study is focused on the study of Seismic demands of different R.C buildings high rise buildings using various analytical techniques for the buildings located in seismic zone V of India medium soil. The Performance of the building is studied in terms of time period, base shear, lateral displacements, storey drifts in linear static and linear dynamic analysis for with and without fluid viscous dampers building G+20 storey models.

The seismic analysis is carried out by equivalent static method and response spectrum method for G+20 storey building with unsymmetrical in plan. The following are the conclusions which can be concluded from the present study, which are as follows.

1. The fundamental natural period of the structure increases due to lesser stiffness of the bare frame buildings compared to buildings having fluid viscous dampers.
2. The base shears due to seismic forces for the building with fluid viscous dampers are more than the base shear obtained for without fluid viscous dampers.
3. Compared to the regular building the storey displacement decreases for the buildings having fluid viscous dampers. Addition of fluid viscous dampers in the building will result in drastic reduction of lateral displacement of the building there by in turn assures the safety of the structure.
4. The storey drift increases in regular building as compared to building having fluid viscous dampers. The addition of fluid viscous dampers in the building drastically reduces the inter storey drift when compared to that of building without fluid viscous dampers.

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AppendixA

Design Data For All The Buildings

Structure	SMRF
No.ofstorey	G+20
Storeyheight	3.5m
Typeofbuildinguse	Commercial
Seismiczone	V
MaterialProperties	
Young'smodulus ofM20concrete,E	22.36x 10^6kN/m^2

Grade ofconcrete	M_{35}(beams,slabandcolumns)
Grade ofsteel	F_e415
Densityofreinforcedconcrete	25kN/m^3
MemberProperties	
Slab	0.2m
Beam(forall models)	0.30x 0.60m
G+20	
Columnsize(Upto5th storey)	0.9x0.9m
Columnsize(6th to 10th storey)	0.8x0.8m
Columnsize(11th to 15th storey)	0.7x0.7m
Columnsize(16th to 21st storey)	0.6x0.6m
AssumedDeadLoadIntensities	
Rooffinishes(DPC)	1.5kN/m^2
Floor finishes	1.0kN/m^2
LiveLoadIntensities	
Floor	3.0kN/m^2

LINK (FluidViscous Dampers) PROPERTIES		
1)	EffectiveStiffness,KN/m	
a)	G+20	43664
2)	DampingCo-efficient,KN-s/m	
a)	G+20	8843

IS:1893-2002EQUIVALENTSTATICMETHOD

Zo	V
Zonefactor,Z(Table2)	0
Importancefactor,I(Table6)	1
Responsereductionfactor,R (Table7)	5
Dampingratio	5%(forRCframedbuilding)

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Comparative Analysis between Different Commonly used Lateral Load Resisting Systems in Reinforced Concrete Buildings

By Rasool.Owais & Tantray. Manzoor Ahmad
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Abstract- The concept of tall structures is not new to the world, yet the trend of high-rise construction started in the nineteenth century. High-rise or multi-storey buildings are being constructed either to cater for a growing population or as a landmark to boost a country's name and get recognition. Any structure, to be reliable and durable, must be designed to withstand gravity, wind, earthquakes, equipment and snow loads, to be able to resist high or low temperatures, and to assimilate vibrations and absorb noises. This has brought more challenges for the engineers to cater both gravity loads as well as lateral loads. Earlier buildings were designed for the gravity loads but now, because of height and seismic zone, the engineers have taken care of lateral loads due to earthquake and wind forces. Seismic zone plays an important role in the earthquake resistant design of building structures because the zone factor changes as the seismic intensity changes from low to very severe. In present research we have used square grid of 12m in each direction of 4m bay in each direction in seismic zone 5.Software used is Staad proV8i select series 5 and the work has been carried out for the different cases with lateral load resisting systems like Shear wall, Bracing, Moment Resisting Frames and check their efficiency by comparing nodal displacements, relative displacement of beams, maximum moments and shear forces in beams and thereby predicting their efficiency.

Keywords: *bare frame, bracings, shear walls, lateral load resisting systems, seismic zone.*

GJRE-E Classification : FOR Code: 090506, 090599

COMPARATIVEANALYSISBETWEENDIFFERENTCOMMONLYUSEDLATERALLOADRESISTINGSYSTEMSINREINFORCEDCONCRETEBUILDINGS

Strictly as per the compliance and regulations of :

Comparative Analysis between Different Commonly used Lateral Load Resisting Systems in Reinforced Concrete Buildings

Rasool.Owais [α] & Tantray. Manzoor Ahmad [σ]

Abstract- The concept of tall structures is not new to the world, yet the trend of high-rise construction started in the nineteenth century. High-rise or multi-storey buildings are being constructed either to cater for a growing population or as a landmark to boost a country's name and get recognition. Any structure, to be reliable and durable, must be designed to withstand gravity, wind, earthquakes, equipment and snow loads, to be able to resist high or low temperatures, and to assimilate vibrations and absorb noises. This has brought more challenges for the engineers to cater both gravity loads as well as lateral loads. Earlier buildings were designed for the gravity loads but now, because of height and seismic zone, the engineers have taken care of lateral loads due to earthquake and wind forces. Seismic zone plays an important role in the earthquake resistant design of building structures because the zone factor changes as the seismic intensity changes from low to very severe. In present research we have used square grid of 12m in each direction of 4m bay in each direction in seismic zone 5.Software used is Staad proV8i select series 5 and the work has been carried out for the different cases with lateral load resisting systems like Shear wall, Bracing, Moment Resisting Frames and check their efficiency by comparing nodal displacements, relative displacement of beams, maximum moments and shear forces in beams and thereby predicting their efficiency.

Keywords: bare frame, bracings, shear walls, lateral load resisting systems, seismic zone.

I. Introduction

Buildings are subjected to two types of load (i) Vertical load due to gravity, and (ii) Lateral load due to earthquake and wind. The structural system of the building has to cater for both the types of load. The structural system of a building may also be visualized as consisting of two components (i) Horizontal framing system, consisting of slabs and beams, which is primarily responsible for transfer of vertical load to the vertical framing system and (ii) Vertical framing system, consisting of beams and columns, which is primarily responsible for transfer of lateral load to foundation. However the two components work in conjunction with each other. The old practice before 1960s had been to design buildings primarily for vertical loading and to check the adequacy of the structure for safety against lateral loads in a cursory manner. It has been established now that the design of a multi-storey building is governed by lateral loads and it should be prime concern of the designer to provide adequately safe structure against lateral loads. Further, the old buildings were having substantial non-structural masonry walls, partitions and connected staircase. These provided a significant safety margin against lateral loading. The modern buildings are having light curtain walls, lightweight flexible partitions along with high strength concrete and steel reinforcement. This reduces the safety margins provided by non-structural components. A number of structural systems have been developed in the last century for optimal transfer of lateral load. The ideal design is that in which no premium is there for lateral load i.e. the stress due to lateral loads is accommodated within the 33% increase in the permissible stresses. This design may not be possible but our aim is to reduce the premium as far as possible.

II. Lateral Load Resisting Structural Systems

A number of structural systems to cater the varying architectural needs are available in steel as well as concrete. Nowadays, computers are widely used for analysis of structures, as computers and software are cheaply available. For proper design of structure an understanding of the behavior of the structural system is necessary. Otherwise, the designer is bound to make mistakes in the modeling of the structure and may have erroneous designs, whatever sophisticated software he may be using. The understanding of the behavior is also necessary for the executing engineer, so that he can understand the critical actions in the structure and can take special precautions in the construction. The following sections present an overview of the behavior of various structural systems under lateral loading.

a) Framed structures

The frames derive their lateral load resistance from the rigidity of connections between beams and columns. The behaviour of frames is straightforward and their computer modeling is simple. A number of softwares are available for analysis of frame structures.

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The frames are infilled by masonry panels for the purpose of partition. These partitions are considered to be non-structural and their contribution to lateral load resistance is generally ignored. The behaviour of these panels is complex. These act as diagonal bracing members before failing and falling apart from the frame. In many cases, under severe shaking due to earthquake, these fail and fall apart before the frame is subjected to the ultimate load and that is why their contribution in lateral load resistance is not considered. However, presence of masonry panels alters the dynamic characteristics of frames and the behaviour is particularly complex when the ground storey of the frame buildings does not have masonry infills for the purpose of parking. Such buildings behave as soft ground storey. There is a sudden change in the stiffness of the building at the first floor level. This increases the storey drift and ductility demand of the ground storey tremendously and may lead to failure of the ground storey due to insufficient ductility. In such situation a safe approach to design the buildings with open ground storey for parking purpose is to increase the stiffness and ductility of the ground storey by bigger sections of beams and columns and closely spaced stirrups. In case of RC frame buildings, the floor slabs are usually casted monolithically with the frames. The floor slabs are quite rigid in their plane and are responsible for distribution of lateral load among the various frames. This action should be properly modeled in the space frame model. The modeling is particularly important in buildings having large differences in lateral stiffness of various lateral load resisting components and asymmetric buildings.

b) Shear wall structures

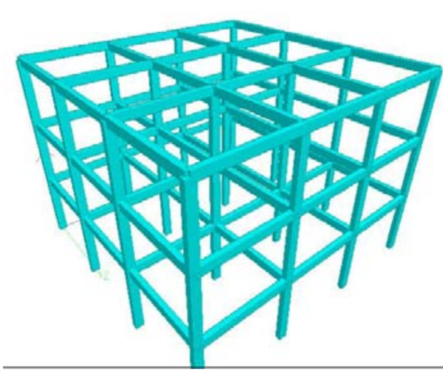
Shear wall is a slender vertical cantilever resisting the lateral load with or without frames. The behaviour of a shear wall is opposite to what its name suggests. A shear wall primarily resists the lateral load in flexure with very little shear deformations. The deformation of a shear wall is different than that of a frame. Therefore, when used in conjunction with frame, shear wall results in complex interaction with the resultant lateral load on the shear wall and frame varying in a complex manner along the height.

c) Braced frame system

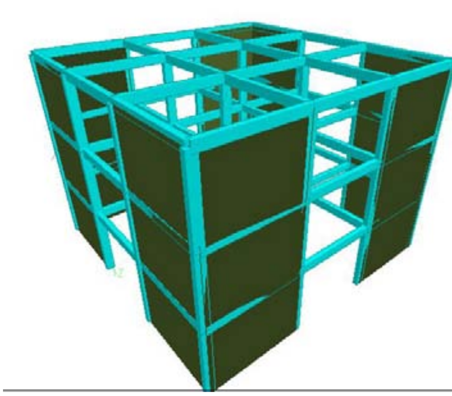
In braced frames the lateral resistance of the structure is provided by diagonal members that together with the beams form the web of the vertical truss with the columns acting as chords. Because the horizontal shear on the building is resisted by the horizontal components of the axial tensile and compressive actions in the web members, bracing systems are highly efficient in resisting lateral loads. Bracing is generally regarded as an exclusive steel system but nowadays steel bracings are also used in reinforced concrete frames. The efficiency of bracing in being able to produce a laterally very stiff structure for a minimum of additional material makes it an economical structural form for any height of building, up to the very tallest. An additional advantage of fully triangulated bracing is that the beams usually participate only minimally in the lateral bracing action. A major disadvantage of diagonal bracing is that it obstructs the internal planning and the location of windows and doors. For this reason braced bents are usually incorporated internally along wall and partition lines and especially around elevator, stair, and service shafts. More recently external larger scale bracing extending over many stories and bays has been used to produce not only highly efficient structures but aesthetically attractive buildings. Braces are of two types, concentric and eccentric. Concentric braces connect at the beam column intersection, whereas eccentric braces connect to the beam at some distance away from the beam column intersection. These structures with braced frames increase the lateral strength and also the stiffness of the structural system and hence reduce the drift.

III. Cases of Study

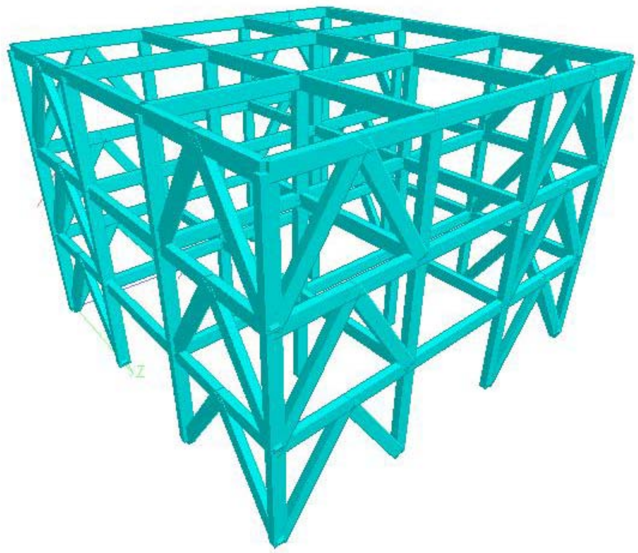
1] Case 1: Bare Frame
2] Case 2: Shear Wall at Corners
3] Case 3: Bracings at Corners



Case 1 : Bare Frame (Mrf)



Case 2 : Shear Wall at Corners



Case 3 : Bracing at Corners

a) Study parameters

a) Type of building: Multi Storied Building.
b) Zone: V
c) Type of soil: Medium
d) Plan of the Building: 12X12
e) Each Bay Size: 4m
f) Height of Building: 9m
g) Floor to floor height: 3mts.
h) Beams: 0.2mX0.35m
i) Columns: 0.2mX0.35m
j) Shear Wall thickness: 0.2m.
k) Live load: 2kN/m2.
l) Dead load of external wall as UDL: 12kN/m
m) Dead load of internal wall as UDL: 6kN/m
n) Damping ratio: 0.05%.

IV. Objectives of Study

Comparing maximum nodal displacements, maximum relative displacement of beams reactions, vertical reactions, maximum bending moments, maximum shear forces, displaced profiles.

V. Results

Table1: Maximum nodal displacement comparison between three lateral load resisting systems

	RESULTANT DISPLACEMENT (mm)		
	MRF	SHEAR WALL	BRACED TYPES
Max X	5.893	3.731	4.209
Min X	3.612	2.391	2.384
Max Y	6.895	0.257	0.213
Min Y	6.201	4.628	3.426
Max Z	6.895	2.803	3.103
Min Z	6.895	2.803	3.103
Max rX	5.408	0.907	2.253
Min rX	5.408	0.681	2.253
Max rY	3.001	3.569	3.238
Min rY	3.001	3.570	3.238
Max rZ	3.871	1.319	2.869
Min rZ	5.893	3.731	4.209
Max Rst	6.895	4.629	4.743

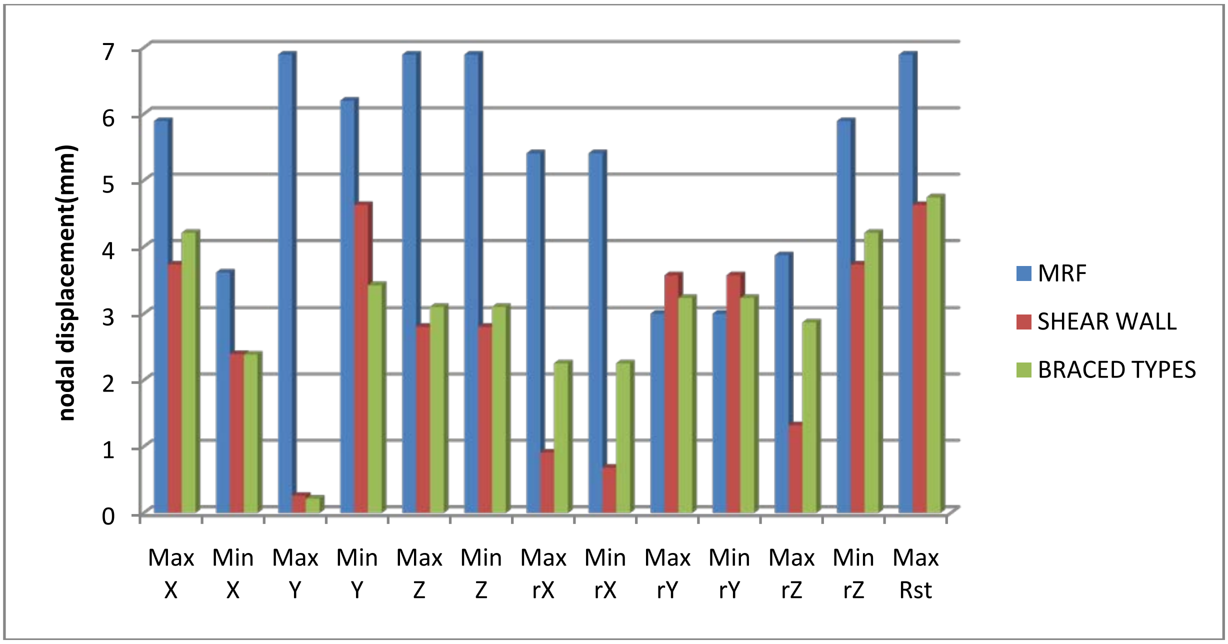


Fig. 1 : Graphical representation of maximum nodal displacement

Table 2 : Comparison of positive maximum beam moments between three lateral load resisting systems (only 10 beams compared)

Beam	L/C	MRF		SHEAR WALL		BRACED	
		Max My(kNm)	Max Mz(kNm)	Max My(kNm)	Max Mz(knm	Max My(kNm	Max Mz(knm
1	ELX+	0.078	6.209	0.506	0.054	0.755	0.224
	DL	0.001	26.334	0.062	26.301	0.254	16.625
	1.5(DL+LL ELX+)	0.116	54.021	0.716	44.814	1.578	27.728
2	ELX+	0.05	5.569	0.054	0.910	0.259	0.893
	DL		25.142		24.970		23.145
	1.5(DL+LL+ELX+)	0.075	51.116	0.001	43.843	0.086	40.60
3	ELX+	0.064	6.995	0.264	0.164	0.479	0.029
	DL	0.001	26.334	0.066	26.357	0.490	16.154
	1.5(DL+LL+ELX+)	0.097	44.405	0.524	44.747	1.689	26.738
4	ELX+	0.183		1.152	44.186	0.058	0.372
	DL	0.001		0.075		0.616	1.442
	1.5(DL+LL+ELX+)	0.274	51.041	1.607	44.186	1.047	2.230
5	ELX+	0.120	5.073	0.191	1.092	0.018	0.514
	DL		24.76		24.826	4.419	4.571
	1.5(DL+LL+ELX+)	0.179	49.708	0.214	43.844	8.579	7.698
6	ELX+	0.151	6.003	0.625	0.074	0.039	0.514
	DL	0.001	25.330	0.081	26.001	4.408	2.208
	1.5(DL+LL+ELX+)	0.227	47.142	1.090	44.325	8.678	4.711
7	ELX+	0.267	2.629	1.750	0.047	0.031	0.372
	DL	0.003	26.82		27.132	0.675	1.032
	1.5(DL+LL+ELX+)	0.405	49.427	2.565	45.838	0.960	2.206

8	ELX+	0.176	2.388	0.555	0.949	0.603	4.285
	DL		25.42	0.195	25.008	0.187	25.037
	1.5(DL+LL+ELX+)	0.264	46.794	1.155	43.962	1.265	54.127
9	ELX+	0.220	3.099	1.102	0.224	0.329	3.850
	DL	0.003	26.828		27.157	0.014	23.886
	1.5(DL+LL+ELX+)	0.326	41.539	1.210	46.549	0.519	51.65
10	ELX+	0.001	6.798	0.007	0.340	0.465	4.856
	DL	5.808	8.572	2.481	5.215	0.196	25.402
	1.5(DL+LL+ELX+)	9.967	9.824	4.224	8.851	0.489	44.043

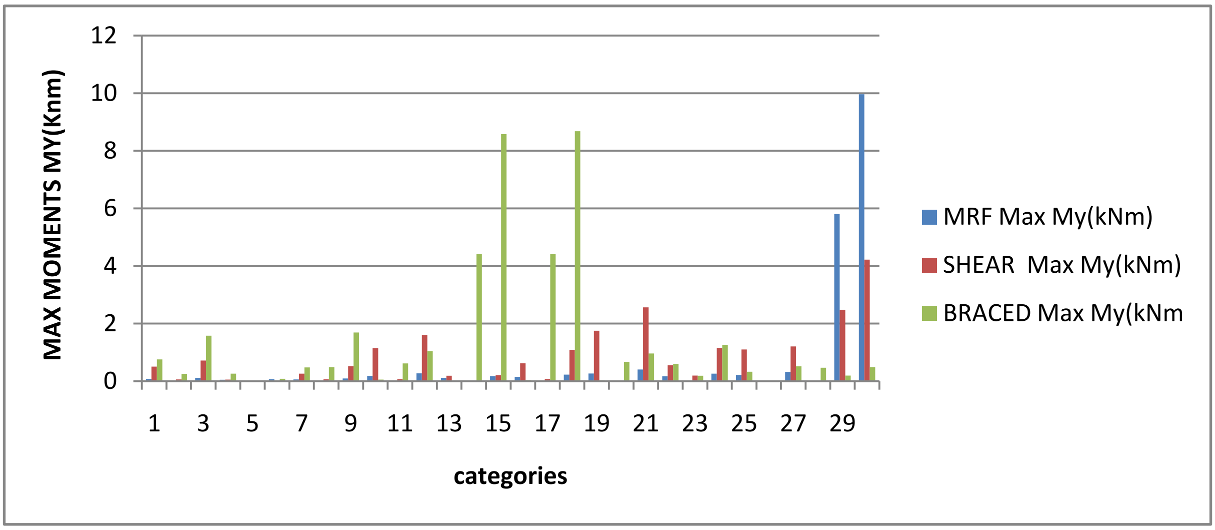


Fig. 2 : Comparison of positive maximum beam moments along vertical direction

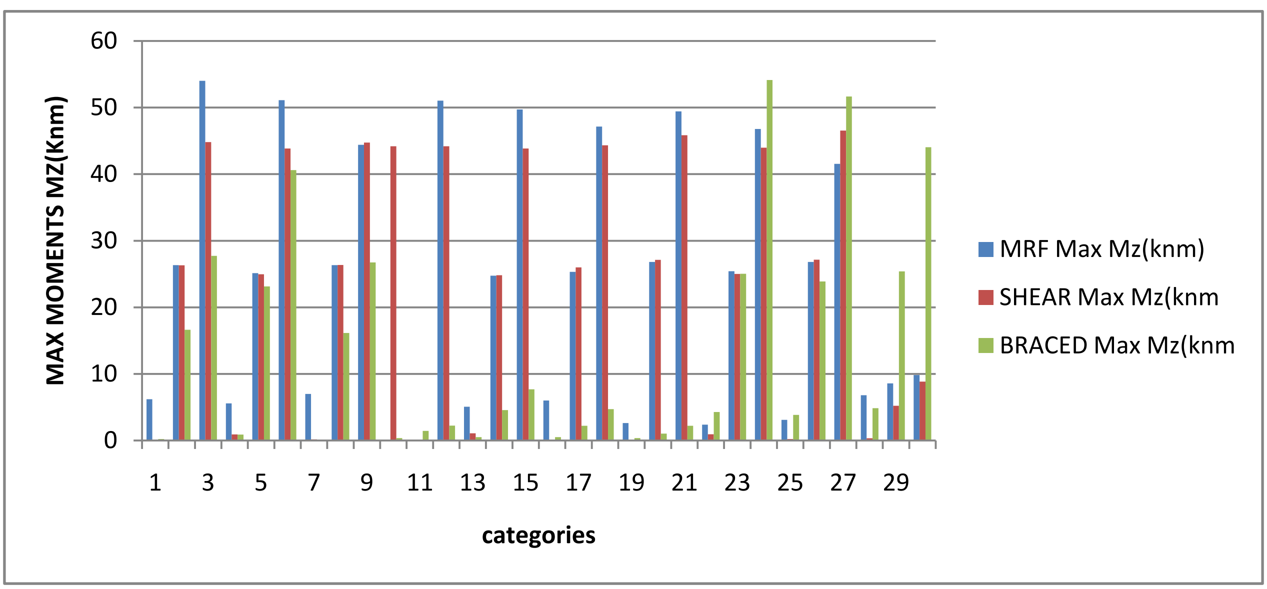


Fig. 3 : Comparison of positive maximum beam moments along horizontal direction

Table 3 : Comparison of positive maximum shear forces between three lateral load resisting systems (only 10 beams compared)

Beam	Load cases	MRF		SHEAR WALL		BRACED	
		Max FZ(kNm)	Max FY(kNm)	Max FZ(kNm)	Max FY(kNm)	Max FZ(kNm)	Max FY(kNm)
1	ELX+						
	DL		33.683	0.020	34.080		5.095
	1.5(DL+LL ELX+)		51.298		56.799		7.613
2	ELX+						
	DL		35.299	0.002	35.297		35.285
	1.5(DL+LL+ELX+)		54.711		58.263		58.258
3	ELX+						
	DL	0.001	36.914		36.563		8.088
	1.5(DL+LL+ELX+)		56.695		61.012		13.001
4	ELX+						
	DL		34.540	0.035	34.335	0.03	0.121
	1.5(DL+LL+ELX+)		53.471		57.303	0.582	
5	ELX+						0.264
	DL		35.299	0.009	35.302	2.209	
	1.5(DL+LL+ELX+)		55.143		58.135	4.289	
6	ELX+					0.019	0.264
	DL		36.057		36.249	2.203	2.249
	1.5(DL+LL+ELX+)		55.847		60.555	4.337	4.395
7	ELX+				0.067		0.121
	DL	0.001	32.798		33.296	0.381	0.769
	1.5(DL+LL+ELX+)		52.608		55.628	0.552	1.385
8	ELX+						
	DL		35.299		35.298		29.814
	1.5(DL+LL+ELX+)		57.175		58.225		52.913
9	ELX+				0.0698		
	DL		37.799		37.330		31.245
	1.5(DL+LL+ELX+)		60.992		62.521		55.980
10	ELX+		3.344		0.125		
	DL	2.9		1.246		0.075	32.959
	1.5(DL+LL+ELX+)						58.392

Table 4 : Comparison of maximum relative displacement of beams for single beam

BEAM	L/C	MRF	SHEAR	BRACED
1	ELX +	0.144	0.058	0.039
	ELX -	0.144	0.058	0.039
	ELX +	0.006	0.037	0.014
	ELX -	0.006	0.037	0.014
	DL	1.032	0.935	0.085
	LL	0.149	0.135	0.006
	WLX +	0.088	0.023	0.032
	WLX -	0.086	0.022	0.021
	WLX +	0.016	0.027	0.011
	WLX -	0.016	0.026	0.016
	1.5(DL+LL+ELX+)	1.862	1.617	0.185
	1.5(DL+LL+ELX -)	1.818	1.608	0.151

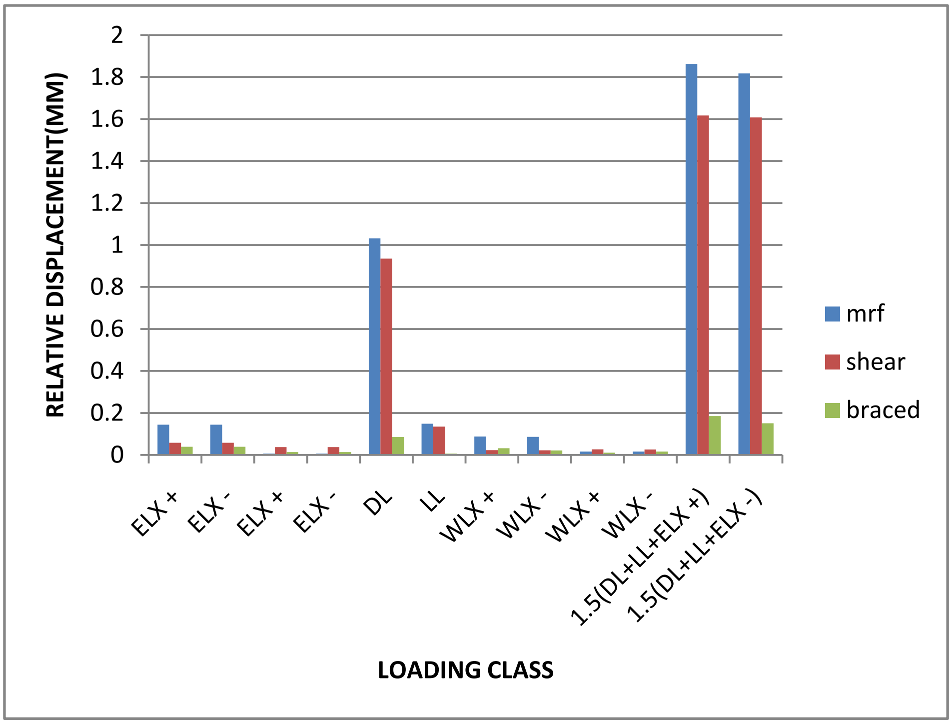


Fig. 4 : Comparison of maximum relative displacement for single beam

Table 5 : Comparison of reaction summary

	MRF		SHEAR		BRACED	
	FY vertical	MY vertical	FY vertical	MY vertical	FY vertical	MY vertical
MAX FX	-1.172	0.011	871	-0.032	818.046	-0.843
MAX FY	759.429	-0.017	971.502	-0.346	899.904	-0.423
MAX FZ	542.445	-0.041	971.502	-0.346	871.568	-0.127
MAX MX	-2.590	-0.013	970.063	0.342	751.819	0.380
MAX MY	344.128	0.076	804.164	0.631	790.893	0.929
MAX MZ	574.406	-0.026	579.191	0.159	4.9	-0.856

VI. Conclusions

From the above study of comparison between three common lateral load resisting systems, the following results have been obtained:

1. The nodal displacement both translational and rotational for Shear wall was least among all the three lateral load resisting systems.
2. Bending moment was comparatively lesser in Bracing lateral load resisting system than Shear wall and Moment Resisting Frame.
3. Shear force in beams was found least in Bracing lateral load resisting system as compared to Shear wall and Moment Resisting Frame.
4. Relative displacement was found comparatively lesser in Bracing lateral load resisting system than Shear wall and Moment Resisting Frame.
5. Base reactions were higher in Shear and Bracing lateral load resisting systems than Moment resisting frames.

VII. Conclusion

Bracing type of lateral load resisting system is most effective in reducing displacements and forces in the members and is economical way of increasing the lateral stiffness of the building.

References Références Referencias

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2. Lateral Load analysis of R.C.C. Building-IJMER www.ijmer.com/papers/vol3_issue3/BH33142814...
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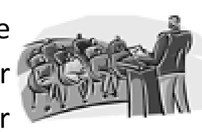

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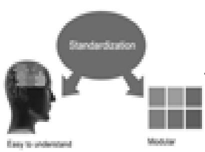

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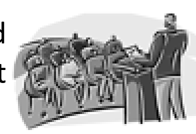

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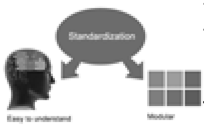

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Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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