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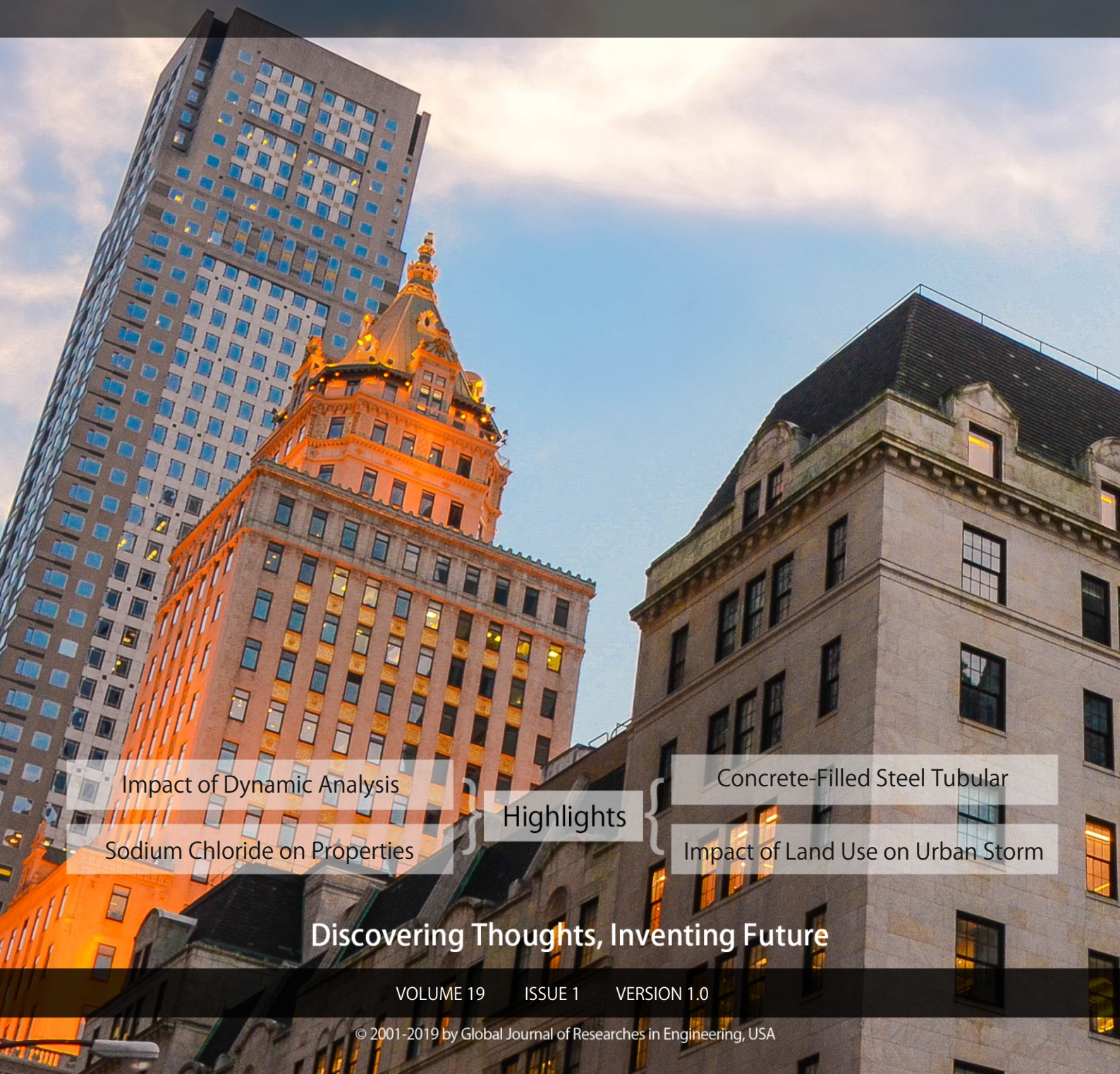

Impact of Dynamic Analysis

Sodium Chloride on Properties

Highlights

Concrete-Filled Steel Tubular

Impact of Land Use on Urban Storm

Discovering Thoughts, Inventing Future

VOLUME 19 ISSUE 1 VERSION 1.0

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Nonlinear Analysis of Edge Joint on T-Shaped Concrete-Filled Steel Tubular Column-H-Shaped Steel Beam Seismic Performance based on ABAQUS

By Yadong Bian, Yichuan Tian, Yi Zhao , Long Cheng, Cheng Hong, Zhicheng
Zhicheng Gao & Jiliang Li
Beihang University

Abstract- To comprehensively analyze the seismic performance and failure modes of edge joint, which is composed of T-shaped concrete-filled steel tubular column and H-shaped steel beam, the joint was imposed through low frequency cycling loading. Model of edge joint was established by the nonlinear finite element software ABAQUS. The effect of different parameters, such as axial compression ratio and side plate extension length, on the seismic performance were simulated. The results indicates that the buckling of the steel beam occurs at the lateral extension of the side plate due to the strengthening of the side plate; the axial compression ratio has no obvious effect on the ultimate load; the increase of the side plate length can effectively improve the ultimate load.

Keywords: t-shaped concrete-filled steel tubular column; H-shaped steel beam; Seismic performance of joint; finite element analysis.

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Nonlinear Analysis of Edge Joint on T-Shaped Concrete-Filled Steel Tubular Column-H-Shaped Steel Beam Seismic Performance based on ABAQUS

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Abstract- To comprehensively analyze the seismic performance and failure modes of edge joint, which is composed of T-shaped concrete-filled steel tubular column and H-shaped steel beam, the joint was imposed through low frequency cycling loading. Model of edge joint was established by the nonlinear finite element software ABAQUS. The effect of different parameters, such as axial compression ratio and side plate extension length, on the seismic performance were simulated. The results indicates that the buckling of the steel beam occurs at the lateral extension of the side plate due to the strengthening of the side plate; the axial compression ratio has no obvious effect on the ultimate load; the increase of the side plate length can effectively improve the ultimate load.

Keywords: t-shaped concrete-filled steel tubular column; H-shaped steel beam; seismic performance of joint; finite element analysis.

I. Introduction

The frame structure of concrete-filled steel tubular special-shaped columns and steel beams has attracted increasing applications in high-rise buildings and long span bridges. It not only has high bearing capacity of concrete-filled steel tube (CFST), good deformation capacity and overcomes the disadvantage of special shaped reinforced concrete structure, but also steel tube can be served as form work to pure core concrete, and saves the constructing cost of using formwork, and accelerates the constructing speed [1]. The frame structure composed of concrete-filled steel tubular columns and steel beam has become a kind of seismic structure with many applications. At present, the joints mainly adopt outer-diaphragm, internal-diaphragm, bearing pin and so on rigid connection or hinge connection form [2]. According to the distribution position of the frame column, the composite joints can be divided into the edge joint, the angular joint and the middle joint. The edge joint is connected by the edge column of frame structure and the beam. The thickness of flange on T shape column is equal tothe thickness of wall. No matter CFST or Reinforced Concrete (RC) is the same, the seismicper formance is different. However, the joint is the key part of the composite structure design, itsrationality is directly related to the safety of the structure and the economy of the project. Many different joint sizes, joint categories and connection types have been used in various engineering for different requirements. Thus, in order to obtain the seismic behaviors of the composite joint, it is necessary to study the influence, with the change of axial compression ratio and side plate extension length.

In recent years, many scholars have studied the seismic behaviors of different kinds of composite joints on various structure by analytical, experimental and finite element (FE) simulation methods. While, most of them focus on other types of steel tubular special-shaped column-steel beam frame joints. The seismic behavior of joint on T-shaped CFST and H-shaped steel beam is less studied. The domestic scholars have put forward a variety of joint forms on CFST columns and carried out experimental research and theoretical analysis [3-9]. Zhou Peng et al. [1] studied the failure characteristics and seismic performance of rectangular steel tubular special-shaped column-steel beam frame joints. Foreign scholars such as Ataei et al. [10] studied the end-plate connection joint in the beam-column composite joint. Hwang et al. [11] studied the seismic behavior of the joint of U-shaped steel-concrete composite beams and RC columns. XU et al. [12] analyzed the seismic behavior of cross section joints of CFST columns and steel girders under different axial compression ratios. Fukumoto et al.[13] studied the joint specimens of high-strength steel tubular columns and steel beam, and the types of the joints include inner partition joint of square steel tubular columns-steel beam and outer partition joint of concrete circular steel tube-steel beam. Kubota et al.[14] proposed a separate type of outer diaphragm joint with square Steel tubular column and H-shaped steel beam, which is less welding work and easier to

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construct than the traditional outer-diaphragm. The experimental results show that the mechanical properties of the separated outer-diaphragm joint is similar to the traditional outer diaphragm. Peng Zhong et al. [15] proposed experimental and numerical studies on the seismic performance of the new end-plate connection between T-shaped CFST columns and reinforced concrete (RC) beams with slabs. Peng Zhong et al. [16] studied seismic behaviour of innovative ringbar reinforced connections composed of T-shaped CFST columns and RC beams with slabs. The comparison between the FE analysis and the experimental results demonstrates the accuracy of the proposed model. Hosseini Farshid et al. [17] investigated the use of engineered cementitious composites (ECC) in 3-D exterior beam-column connections to improve building seismic performance. Mou Ben et al. [18] done an experimental investigation on the seismic behavior of a novel steel concrete composite beam-to-column connections reinforced by outer-annular-stiffener.

In this paper, the joint form of T shaped CFST columns-H steel beam is proposed. The failure mode and seismic performance of T-shaped CFST column-H-shaped steel beam joint is studied, based on the nonlinear finite element software ABAQUS.

II. Establishment of Finite element Model

T-shaped CFST column-H-shaped steel beam edge joint is welded by T-shaped CFST column and H-shaped steel beam, and is reinforced by side panels. Fig.1 shows the specimen size and large sample. The T-shaped CFST column section size, wall thickness of steel tube, column height and steel beam size are 300mm×100mm×200mm×100mm, 5mm, 1800mm, and 250mm×100mm×4mm×4mm, respectively. The properties of steel material are presented in Table 1. The mechanical properties of concrete are shown in Table 2. The finite element model number and parameters settings are summarized in Table 3.

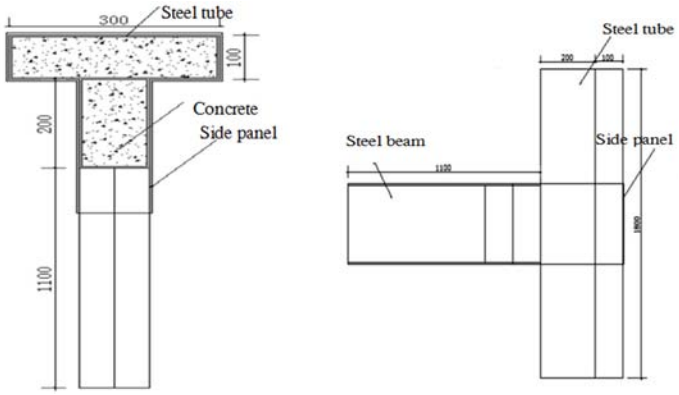


Fig. 1: Joint large sample

Table 1: Material properties of steel

Steel model	Elastic modulus	Yield strength	Ultimate strength	Poisson's ratio
Q235	2.06×10^5Mpa	235Mpa	370Mpa	0.3

Table 2: Mechanical properties of concrete

Concrete strength grade	Elastic modulus	Axial compressive strength standard value	Axial compressive strength design value	Poisson's ratio
C40	3.25×104Mpa	26.8Mpa	19.1Mpa	0.2

Table 3: Comparison of finite element model parameters

Model number	Axial compression ratio	Side plate extension length(mm)	Concrete strength grade	Steel model	Steel beam size(mm)
A	0.2	258	C40	Q235	250×100×4×4
B	0.4	258	C40	Q235	250×100×4×4
C	0.6	258	C40	Q235	250×100×4×4
D	0.6	308	C40	235	250×100×4×4
E	0.6	356	C40	Q235	250×100×4×4

The three-dimensional solid element (C3D8R) with eight-node reduced integral scheme is used to build the above-mentioned joint model, applying non-linear finite element software ABAQUS. The model mainly includes T-shaped CFST columns, H-shaped steel beams and side plates. The properties of the finite element model are divided into two categories. First, the establishment of concrete properties, including elasticity and concrete damage plasticity, applied to the core concrete. Second, the establishment of steel properties, including elasticity and plasticity, applied to T-shaped steel tube, Hshaped steel beams and side panels. The interaction between the T-shaped steel tube, the H-shaped steel beam and the side plate is the "Tie" provided in ABAQUS. The interaction between the T-shaped steel tube and the core concrete, between the side plate and the core concrete, selects the "Surface-to surface contact" provided in ABAQUS, where the " Surface-to-surface contact " interaction between the T-shaped steel tube and the core concrete includes "Normal Behavior"and "Tangential Behavior", and the " Surface-to-surface contact " interaction between the side plate and the core concrete only includes "Normal Behavior".

The settings of the finite element models are depended on two loading steps. In the first step, the side plate of the column top is coupled to the reference point XRP-2 and an axial concentrating force is applied at the reference point XRP-2. The axial pressure is designed to be 1882.78kN, and the vertical load of the column is loaded at the axial compression ratio of 0.2, 0.4 and 0.6, respectively. Afterwards, the beam end section is coupled with the reference point XRP-3, and apply a vertical periodic displacement on the reference point XRP-3. In the finite element model, all degrees of freedom in the bottom hinge are restrained. The displacement of the node in the horizontal direction is restricted at the loading end of the column, and the displacement of the node X direction is restricted at loading end of the beam, shown as Fig.2.

The meshing size has a great influence on the accuracy and computational efficiency of the finite element analysis software ABAQUS. If the size of the finite element model grid is too large, the calculating result of the finite element model may be deviate and even erroneous. If grid is too small, it will take long time to calculate the result. In order to ensure the accuracy of calculation and save the computational resources, the mesh size of the nodal domain is smaller than that of other parts in the process of finite element meshing. The grid diagram is shown as Fig. 3.

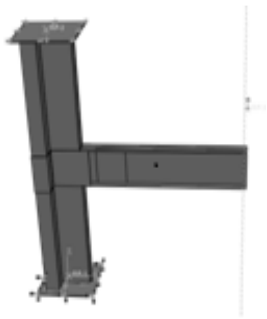


Fig. 2: Finite element model Fig.

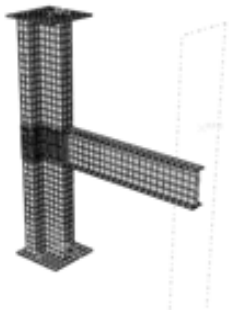


Fig. 3: Finite element meshing

III. Finite Element Calculating Results

a) Stress nephogram analysis

Fig. 4 shows the Mises stress distribution of four locations, including the T-shaped steel tube, the core concrete, the H-shaped steel beam and the side plate. From the figure, the stress of the steel tube is relatively larger on the upper and lower sides of the middle plate of the steel tube, and the stress of the nodal domain becomes smaller, and buckling of the T-shaped column occurs on the upside of side plate and the underside of the side plate. This is because the side plane assumes a lot of stress, to achieve a very good control. In the corner of the core concrete, the stress is relatively larger, because the constraint of the square steel tube is weak in the corner of the core concrete; the stress at the upper and lower flanges of the steel beam joint domain is larger. Since the reinforcing plate constraints, buckling of steel beams occurs in the side plate portion epitaxial portion; the stress of the side plate is large, it plays a very good restraint to the core area of the steel tube, thus reducing the stress of the steel tube in the core area.

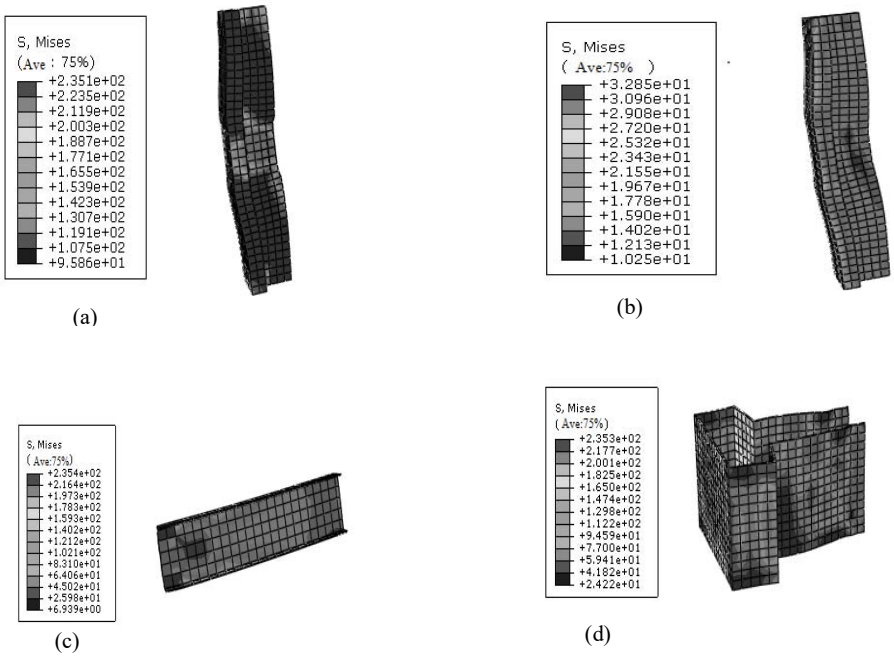
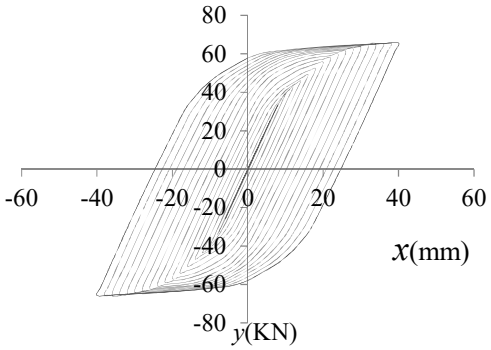


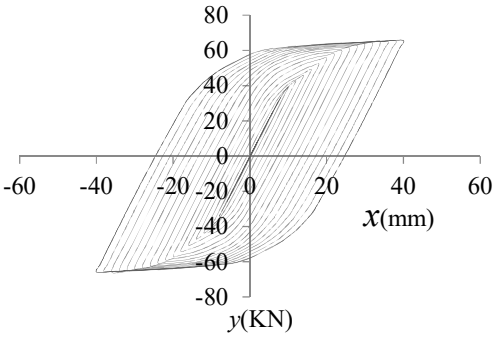
Fig. 4: Stress nephogram

b) Load displacement curve

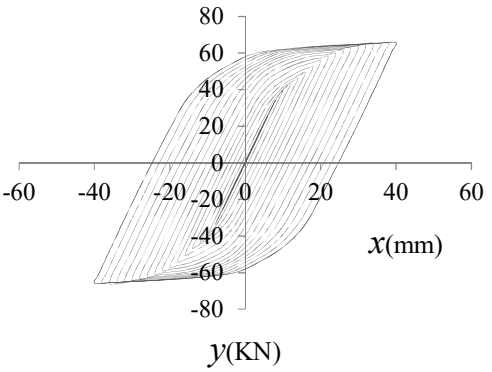
Fig. 5 is the hysteresis curve of each finite element model under the action of low frequency cycling loading. As shown in the figure 5, the hysteresis curves of the different axial compression ratios are universally similar. Before the yield, the curve reflecting the relationship between displacement and load is linear. The specimen is in the elastic stage. With the increase of the displacement load, the steel beam gradually enters the plastic working stage. As the stiffness of the column is much larger than the stiffness of the beam, and the low frequency cycling loading is applied to the end of beam. The increase of the axial load ratio has no obvious effect on the ultimate load. The increase of the lateral extension of the side plate can effectively improve the ultimate load. The hysteresis curves of per models do not shrink, which are full of spindle, and showing good seismic performance of the composite joint.



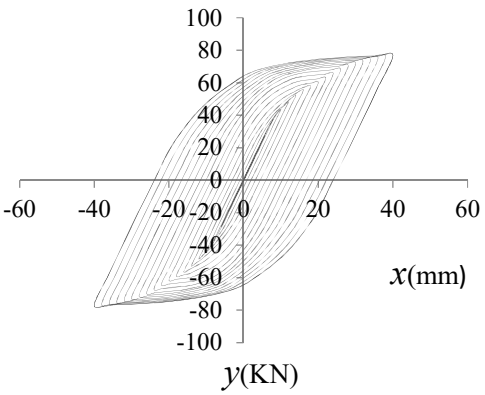
(a) C40, n=0.2, d=258mm



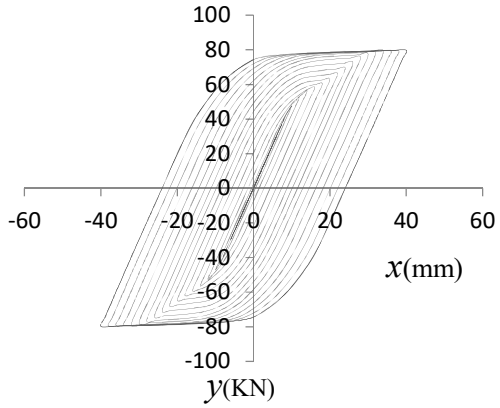
(b) C40, n=0.4, d=258mm



(c) C40, n=0.6, d=258mm



(d) C40, n=0.6, d=308mm



(e) C40, n=0.6, d=358mm

Fig. 5: hysteresis curve

c) Node skeleton curve

Fig. 6 is a comparison of the skeleton curves obtained from the model hysteresis curves of Fig. 5. Fig. 6 (a) is a comparison chart of the skeleton curves corresponding to different axial compression ratios, and Fig. 6 (b) shows the skeleton curve comparison chart of different lateral extension length of the side plate. It can be seen from the figure that the axial compression ratio is similar to the corresponding skeleton curve. The increase of the axial compression ratio has no obvious effect on the ultimate load. The increase of the side plate length can effectively increase the ultimate load. When the lateral extension of the side plate is increased to a certain value, the effect of the increase of the side plate length on the ultimate load is reduced.

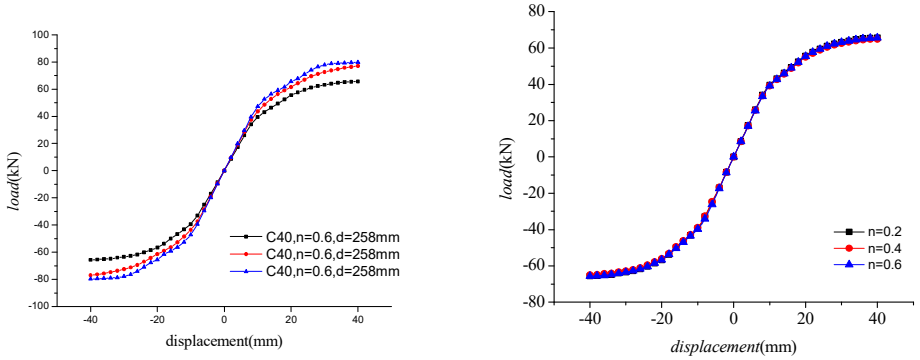


Fig. 6: Comparison of skeleton curves

d) Energy dissipation capacity

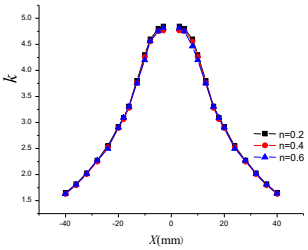
The deformation process of structural members under the action of low frequency cycling loading is also the process of absorbing energy. The energy dissipation capacity of structural members determines the seismic capacity of the structure. The energy dissipation capacity of the join model is mainly evaluated by the equivalent viscous damping coefficient [19].Usually, the average of the reinforced concrete joint is 0.1, and the common steel concrete joint is about 0.3 [20]. Table 4 shows the equivalent viscous damping coefficient corresponding to the hysteresis curve of each finite element model. As shown in the table 4, the equivalent viscous damping coefficient corresponding to each hysteresis curve is close to 0.2, it is larger than the equivalent viscous damping coefficient of the reinforced concrete beam which is 0.1. It indicates that the T shaped CFST column-H-shaped steel beam has good energy dissipation capacity and seismic capacity.

Table 4: The Equivalent viscous damping coefficient of each specimen

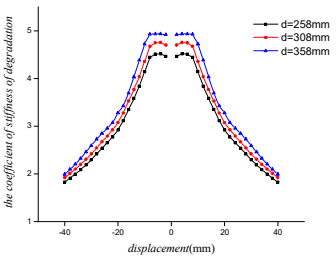
Model number	A	B	C	D	E
h_e	0.193	0.194	0.211	0.254	0.261

e) Stiffness degradation curve

Fig.7 is stiffness degradation curve comparison chart. Fig.7 (a) shows the stiffness degradation curves of the hysteresis curves for finite element models A, B, and C. Fig.7 (b) shows the stiffness degradation curves of the hysteresis curves for finite element models C, D, and E. It can be concluded from the graph that the variation law of the degenerate coefficient of the beam stiffness is normal distribution. With the increase of the beam displacement load, the stiffness degradation of each model is obvious; the influence of the axial compression ratio on the degradation coefficient of the joint stiffness is not obvious. With the increase of the displacement of the side plate, the stiffness of the finite element model increases at the initial loading stage. As the displacement load increases, the loaded steel beam begins to enter the plastic work, and the difference of the stiffness of each member is smaller.



(a) Different axial compression ratio stiffness degradation curve



(b) Degradation curves of elongation stiffness of different side plates

Fig. 7: Stiffness degradation curve

IV. Conclusion

In this paper, the seismic performance of the joint is evaluated, based on the establishment of rationalized T-shaped CFST column-H-shaped steel beam edge joint finite element model. The conclusions are summarized as follows:

1. The buckling of the T column occurs on the upper and lower sides of the side plate, and the buckling of the steel beam occurs at the side plate extension, due to the restraint of the side plate.
2. The increase of the axial load ratio has no obvious effect on the ultimate load, and the increase of the length of the side plate can effectively improve the ultimate load of the beam end, as the stiffness of the column is much larger than the stiffness of the beam, and the low cyclic loading is applied to the beam end.
3. The equivalent viscous damping coefficient corresponding to each hysteresis curve is close to 0.2, which indicates that the T-shaped concrete-filled steel tubular column-H-shaped steel beam node has good energy dissipation capacity.

This paper studies the failure mode and seismic performance of T-shaped concrete-filled steel tubular columns-H-shaped steel beam node, application the finite element numerical simulation. In the future research, it is also necessary to combine finite element simulation with experimental research, and make a more thorough analysis of the node.

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Impact of Dynamic Analysis of High Rise Structure with Dual System under Different type of Soil Conditions, Different type of RC Shear Wall & Different Load Combination, Load Cases

By Mahdi Hosseini & N. V. Ramana Rao
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Abstract- The current research work analyzes thirty storey building in India with C, Box, E, I shape and new shape of RC Shear walls Plus shape, at the center in Concrete Frame Structure with fixed support conditions under different type of soil (Hard, Medium &soft soil) for earthquake zone V as per IS 1893 (part 1) :2002. This design also uses software ETABS by Dynamic analysis (Response Spectrum method). All the analyses have been carried out as per the Indian Standard code books. This work aims to explore the behavior of new shape of RC Shear walls plus shape in high rise structure with dual system with different type of RC Shear under different type of soil condition and different load combination for seismic loading. Estimation of structural response such as lateral load, stiffness, storey drift, storey moment, storey shear, storey displacements, time period , frequency, mode shape, Pier forces and column forces is carried out. It was found that the building which is in box shape shear walls provided at the center core showed better performance in terms of maximum storey displacements, time period.

Keywords: dynamic analysis, structural response, soil condition, rc shear walls, software etabs.

GJRE-E Classification: FOR Code: 290899

Strictly as per the compliance and regulations of:

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Mahdi Hosseini [α] & N. V. Ramana Rao [σ]

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I. Introduction

a) Shear Wall Structure

The usefulness of shear walls in the framing of buildings has long been recognized. Walls situated in advantageous positions in a building can form an efficient lateral-force-resisting system, simultaneously fulfilling other functional requirements. Shear Wall is a structural element used to resist lateral, horizontal, and shear forces parallel to the plane of the wall by: cantilever action for slender walls where the bending deformation is dominant .Truss action for squat/short walls where the shear deformation is dominant. Shear walls are analyzed to resist two types of forces: shear forces and uplift forces.

b) Necessity of Shear Walls

Shear wall system has two distinct advantages over a frame system.

- It provides adequate strength to resist large lateral loads without excessive additional cost.
- It provides adequate stiffness to resist lateral displacements to permissible limits, thus reducing risk of non-structural damage.

c) Earthquake Load

The seismic weight of building is the sum of seismic weight of all the floors. The seismic weight of each floor is its full dead load plus appropriate amount of imposed load, the latter being that part of the imposed loads that may reasonably be expected to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and movable partitions, permanent equipment, a part of the live load, etc. Earthquake forces experienced by a building result from ground motions (accelerations) which are both fluctuating and sometimes dynamic in nature; in fact they reverse directions somewhat chaotically. In theory and practice, the lateral force that a building experiences from an earthquake increases in direct proportion with the acceleration of ground motion at the building site and the mass of the building (i.e., a doubling in ground motion acceleration or building mass will double the load). As the ground accelerates

back and forth during an earthquake it imparts back-and-forth (cyclic) forces to a building through its foundation which is forced to move with the ground.

II. Methodology

Earthquake motion causes vibration of the structure leading to inertia forces. Thus a structure must be able to safely transmit the horizontal and the vertical inertia forces generated in the super structure through the foundation to the ground. Hence, for most of the ordinary structures, earthquake-resistant design requires ensuring that the structure has adequate lateral load carrying capacity.

Quite a few methods are available for the earthquake analysis of buildings; two of them are presented here:

1. Equivalent Static Lateral Force Method (pseudo static method).
2. Dynamic analysis.

i. Response spectrum method.
ii. Time history method.

a) Response Spectrum Method

Dynamic analysis should be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to various lateral load resisting elements, for the following buildings:

- Regular buildings- Those are greater than 40 m in height in zone IV, V and those are greater than 90 m height in zones II,III, and
- Irregular buildings-All framed buildings higher than 12 m in zone IV and V, and those are greater than 40 m in height in zone II and III.

Dynamic analysis may be performed either by time history method or by the response spectrum method. However in either method, the design base shear V_B shall be compared with a base shear V_B calculated using a fundamental period *Ta*. When V_B is less than V_B all the response quantities shall be multiplied by V_B / *Vb,* The values of damping for a building may be taken as 2 and 5 percent of the critical, for the purpose Of dynamic analysis of steel and reinforced concrete buildings, respectively. Therefore, analysis in practice typically uses linear elastic procedures based on the response spectrum method. The response spectrum analysis is the preferred method because it is easier to use. This method is also known as model method or mode superposition method. It is based on the idea that the response of a building is the superposition of the responses of individual modes of vibration, each mode responding with its own particular deformed shape, its own frequency, and with its own model damping.

III. Numerical Analysis

a) Modeling of Building

A symmetrical building of plan 38.5m X 35.5m located with location in zone V, India is considered. Four baysof length 7.5m& one bays of length 8.5m along X - direction and Four bays of length 7.5m& one bays of length 5.5m along Y - direction are provided. Shear Wall is provided at the center core of building model.

Structure 1: This model building with 30 storeysis modeled as a (Dual frame system with shear wall (Plus Shape).The shear wall acts as vertical cantilever at the center of building.

Structure 2: This model building with 30 storeys is modeled as (Dual frame system with shear wall (Box Shape) the shear wall acts as vertical cantilever at the center of building.

Structure 3: This model building with 30 storeys is modeled as (Dual frame system with shear wall (C-Shape).The shear wall acts as vertical cantilever at the center of building.

Structure 4: This model building with 30 storeys is modeled as (Dual frame system with shear wall (E-Shape) the shear wall acts as vertical cantilever at the center of building.

Structure 5: This model building with 30 storeys is modeled as (Dual frame system with shear wall (I-Shape). The shear wall acts as vertical cantilever at the center of building.

b) Load Combinations

As per IS 1893 (Part 1): 2002 Clause no. 6.3.1.2, the following load cases have to be considered for analysis:

1.5 (DL + IL)
1.2 (DL + IL ± EL)
1.5 (DL ± EL)
0.9 DL ± 1.5 EL

Earthquake load must be considered for +X, -X, +Y and –Y directions.

For the purpose of determining the design seismic forces, the country (India) is classified into four seismic zones (II, III, IV, and V).

Details of the Building

Table 1: Details of the Building

Building Parameters	Details
Type of frame	Special RC moment resisting frame fixed at the base
Building plan	38.5m X 35.5m
Number of storeys	30
Floor height	3.5 m
Depth of Slab	225 mm
Size of beam	(300 × 600) mm
Size of column (exterior)	(1250×1250) mm up to story five
Size of column (exterior)	(900×900) mm Above story five
Size of column (interior)	(1250×1250) mm up to story ten
Size of column (interior)	(900×900) mm Above story ten
Spacing between frames	7.5-8.5 m along x - direction 7.5-5.5 m along y - direction
Live load on floor	4 KN/m2
Floor finish	2.5 KN/m2
Wall load	25 KN/m
Grade of Concrete	M 50 concrete
Grade of Steel	Fe 500
Thickness of shear wall	450 mm
Seismic zone	V
Important Factor	1.5
Density of concrete	25 KN/m3
Type of soil	Soft,Medium,Hard Soil Type I=Soft Soil Soil Type II=Medium Soil Soil Type III= Hard Soil
Response spectra	As per IS 1893(Part-1):2002
Damping of structure	5 percent

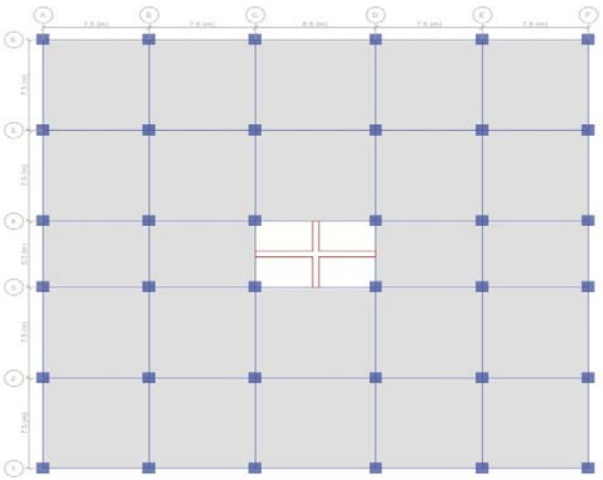

Figure 1: Plan of the Structure 1

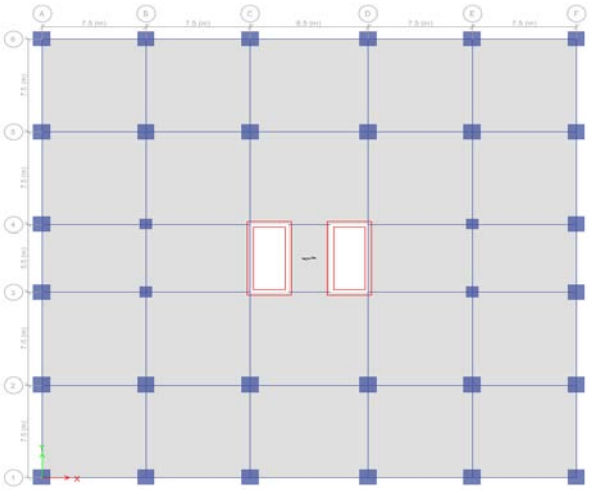

Figure 2: Plan of the Structure 2

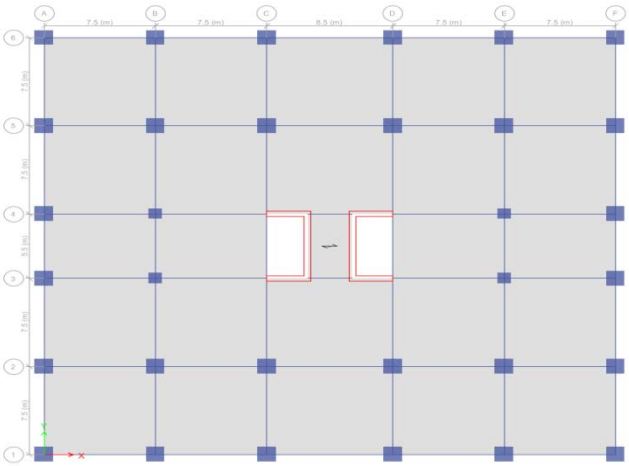

Figure 3: Plan of the Structure 3

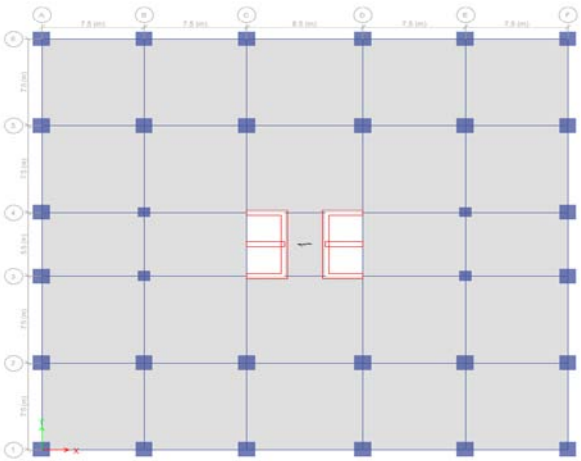

Figure 4: Plan of the Structure 4

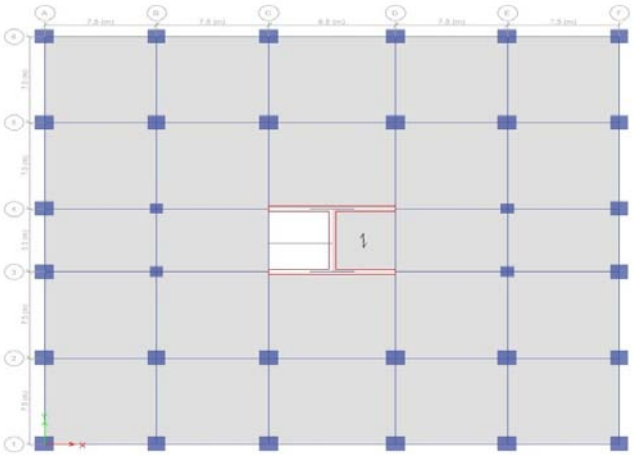

Figure 5: Plan of the Structure 5

IV. Discussion on Results

When a structure is subjected to earthquake, it manifests in the form of vibration. An example force can be resolved into three mutually perpendicular directions-two horizontal directions (X and Y directions) and the vertical direction (Z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are primarily designed for gravity loads-force equal to gravity of mass time in the vertical direction. This can be accounted to the inherent factor used in the design specifications as most structures tend to be adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans those in which stability for design, or for overall stability analysis of structures. The basic intent of design theory for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage, resist moderate earthquakes without structural damage but with some non-structural damage. To avoid collapse during a major earthquake, members must be ductile enough to absorb and dissipate energy by post elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the event of the failure of key elements. When the primary element or system yields or fails, the lateral force can be redistributed to a secondary system to prevent progressive failure.

The structural prototype is prepared and lots of data is been collected from the prototype. All the aspects such as safety of structure in shear, moment and in story drift have been collected. So, In order to check the safety of the structure with established shear walls and all construction of core wall in the center, the graphical values of structure with the shear wall and a simple rigid frame structure need to be compared.

IS 1893 Part1Codal Provisions For Storey Drift Limitations:

The storey drift 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 the purposes of displacement requirements only, it is permissible to use seismic force obtained from the computed fundamental period (T) of the building without the lower bound limit on design seismic force specified in dynamic analysis.

The result obtained from the analysis models will be discussed and compared as follows:
It is observed that

- The maximum storey drift in X-direction occurred at storey 11 th for structure 3 in hard, medium and soft soil.
- The maximum storey drift in X-direction occurred at storey 11 th for structure 4 in hard, medium and soft soil.
- The maximum storey drift in X-direction occurred at storey 14 th for structure 5 in hard, medium and soft soil.
- The time period is 6.298 Sec for structure1 and it is same for different type of soil.
- The Frequency is 0.159cyc/sec for structure1 and it is same for different type of soil.
- The time period is 5.785 Sec for structure2 and it is same for different type of soil.
- The Frequency is 0.173cyc/sec for structure2 and it is same for different type of soil.
- The time period is 6.415 Sec for structure3 and it is same for different type of soil.
- The Frequency is 0.156cyc/sec for structure3 and it is same for different type of soil.
- The time period is 6.375Sec for structure4 and it is same for different type of soil.
- The Frequency is 0.157cyc/sec for structure4 and it is same for different type of soil.
- The time period is 6.382 Sec for structure5 and it is same for different type of soil.
- The Frequency is 0.157cyc/sec for structure5 and it is same for different type of soil.

V. Conclusion

- Time period is a significant factor for the shear wall and its position
- This not only influenced by the type of soil but also by the low time period which is a very significant performance as shown in structure 2.
- Structure two indicates increase in the height of the building, hence there is increase in drift is observed and further reduction at top floor.
- For a better comparison story drift values are smaller values is noted for the center of the building which can be obtained for it shear wall at center.
- As per code, the actual drift is less than permissible drift. The parallel arrangement of shear wall in the center core and outer periphery is giving very good result in controlling drift in both the direction. The performance is better for all the structures with soft soil because it has low storey drift.
- The height of the each storey is 3.5 m. So, the drift limitation as per IS 1893 (part 1): 2002 is 0.004 X 3.5 m = 14 mm. The models show a similar behavior for storey drifts as shown in graph.
- According to Indian standards, storey drifts are found within the limit, IS 1893 (Part1): 2002.specification for earthquake resistant design of structures.
- There is reduction in displacement of shear wall which may increase in building stiffness.
- The displacement is influenced by accommodating shear wall and also by changing soil condition. The performance is better for model with soft soil because it has low displacement.
- For both X and Y directions, the behavior of the displacement graph is similar for all the structures in soil which is soft, Soil which is medium and Hard Soil. The order of maximum storey displacement in both the directions for the models is same.
- The value of the lateral loads in x-direction for all models observed reduction with enhancement of storey level.
- The value of the lateral loads in x-direction for all models in soft soil is less compared with the structure in medium soil and hard soil.
- Lateral loads in X-direction for all models in soft soil <Medium soil < hard soil.
- Percentage of lateral load for all three type of soil is same.
- The value of the Stiffness of Structure in Soft Soil, Medium Soil and Hard Soil in X – direction for load cases EQXP is same.
- The value of the Stiffness of Structure in Soft Soil, Medium Soil and Hard Soil in Y – direction for load cases EQYP is same.
- There is a considerable difference in Pier Moment with a Different type of soils and structures.
- There is a considerable difference in Pier shear force with a Different type of soils and structures.
- There is no considerable difference in Pier axial forces with a Different type of soils and structures.
- It is evident that Pier Torsion in X direction for all structures in soft soil is more than Medium soil and more than hard soil.
- It is evident that Pier Torsion in Y direction for soft soil is less than Medium soil and less than hard soil.
- It is evident that shear walls which are provided from the foundation to the rooftop, are one among important means for executing quake resistant to multi storey building with different type of soil.
- It is observed that the maximum column axial force is diverse with type of soil and placing of the shear wall.
- It is observed that the maximum column shear force in x-direction is influenced by the type of soil and placing of the shear wall.
- It is noted that the maximum column shear force in y-direction has no influence on the type of soil and placing shear wall.
- It is noted that the maximum column torsion is same for all columns in a structure, but is influenced by the type of soil and placing shear wall.
- It is noted that the maximum column moment in x-direction has no influence on the type of soil and shear wall placed.

- It is noted that the maximum column moment in y-direction is influenced by the type of soil and placing of shear wall.
- The Axial force and Moment in the column increases when the type of soil changes from hard to medium and medium to soft. Since the column moment increases as the soil type changes, soil structure interaction must be considered suitable while designing frames for seismic force.
- For severe lateral loads caused by wind load and or earthquake load, the reinforced shear wall is obvious because it produces less deflection and less bending moment in connecting beams under lateral loads than all others structural system.
- ETABS is the robust software which is utilized for analyzing any kind of multi building structures. It can easily analyze 40 floors building structures by its fast and accuracy.
- The shear force resisted by the column frame is decreasing by placing the shear wall and the shear force resisted by the shear wall is increasing. This can be concluded indirectly by observing the maximum column shear force and moment in both directions.
- It is observed that the value of storey moment inx & y-direction is same for the model with a different type of soil and placing shear wall.
- It is observed that the value of stiffness in x& y-direction is same for the model with a different type of soil and placing shear wall.

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Effect of Sodium Chloride on Properties of Bitumen

By Md. Shariful Islam
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Abstract- Nowadays a lot of modifications are taking place throughout the world to develop the existing highway materials to fulfill the demand of increased vehicles. People are at the trend to innovate something new that can do better than it was. Some material produce a good effect and enhance the strength as well as qualities of bitumen. On the other hand, some are responsible for the adverse on the bitumen. In saline areas like coastal regions, the salts play a significant role in the bituminous pavements. Water of sea nearly contains 3% sodium chloride, and evaporation of intake bodies of water has produced huge and extensive deposits of it. We can be economically benefited if salt is used as an admixture to bitumen. But we do not even know the impact, good or bad of the mixing of salt with bitumen. The objective of this paper to find out whether it is desirable or not taking various proportion salt with bitumen and doing the specified test of bitumen. It is observed from the laboratory test that the penetration and ductility values are gradually increased with increase of salt content. The flash point, fire point, and softening point value are stepwise reduced as a percentage of salt content increased. Moreover, it reduces the stability of roads. Mixing of salt to bitumen upgrades workability and it is beneficial in the economical point of view. Finally, moisture effect test on the bituminous mix with the inclusion of salts shows the degradation of strength due to moisture movement.

Keywords: *sodium chloride, bitumen, bituminous mix, flash fire point, stability.*

GJRE-E Classification: *FOR Code: 090599*

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I. Introduction

Bituminous mixes are most commonly used all over the world in pavement construction. Under normal circumstances, conventional bituminous materials if designed and executed properly perform satisfactory. But for applications like roundabouts or where traffic is extremely heavy, stiffer mixes are required which can have large fatigue life and more resistance permanent deformation. Most publications ascribe moisture damage to variables like bitumen properties, aggregate characteristics, hot mix processing, bituminous mixture characteristics, quality control during construction, nature of water at the interface, dynamic effect of traffic loading, type, and properties of anti-stripping additives, and others. The great diversity of variables and differences in earlier research results reported make a prediction of moisture sensitivity difficult. Most mechanistic design methods for bituminous pavements mainly base on fatigue and rutting as the primary design criteria. However, SHRP's mechanistic/analytical approach to pavement design proposed the need to consider resistance to moisture damage as a factor in selection and proportioning of binders and aggregates (McGennis et al., 1995).

The Coastal area, pavement often come across with saline water. In this area, the salts particularly sodium chloride plays an important role in the stability as well as durability of roads. In this situation, the effect of salts on properties of bitumen is important for design and maintenance of the pavements. The present status of literature, indicate that a little work has been conducted to determine the behavioral changes in the bituminous pavements in the present of salts. In this paper, an attempt has been undertaken to study the effect of salts on varies properties of bitumen.

II. The Objective of Study

In recent years, a significant achievement has been made the study in the different field of engineering Also various causes have been determined to take appropriate measures against the determination and detrimental effect. In general, the presence of alkalis and salts produce a harmful on the behavioral aspects of binding materials. In these studies, an attempt has been made to quantify the adverse effects in term of some specific standard tests. The objective of this studies are

- To the effect of salts on the properties of bitumen.
- To determine the variation of strength with the inclusion of salts.
- To observe the effect of water on the strength of bituminous mixes with the inclusion of salts in bitumen.
- To carefully examine the use of salts in the bitumen regarding various properties such as penetration, solubility, ductility, etc.

III. Tested on Bitumen

To determine its behavior and its suitability a variety of tests have been specified by institutions like ASTM, I.S.I, Asphalt Institute, And B.S.I. The various tests of bitumen are followed:

- *Penetration test:* The penetration tests determine the hardness or softness of bitumen by measuring the depth in one-tenth in millimeter to which a standard loaded needle will penetrate vertically in five seconds.

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Figure 1: Penetration test apparatus

- *Softening point test:* The softening point test is the temperature at which the substance attains a particular degree of softening under specified condition test .The softening point of bitumen is usually determined by ring and ball test.

Figure 2: Softening point test apparatus

- *Flash and Fire point test:* Flash and fire point tests is conducted on bitumen to know the safe mixing and application temperature values of particular bitumen grade.
  The flash point of a material is the lowest temperature at which the vapour of a substance momentarily takes fire in the form of a flash under specified condition of test.
  The fire point is the lowest temperature at which the material gets ignited and burns under specified conditions of test.

Figure 3: Flash and Fire point test

- *Ductility test:* The flexible pavement construction at where the bitumen binders are used, it is of significant importance that binders from the ductile thin film around the aggregates. This serves as a satisfactory binder in improving physical interlocking of the aggregates. The binder material which does not possess sufficient ductility would crack and thus provide previous pavement surface. It has been started by some agencies that the penetration and ductility properties go together, but depending upon the chemical composition and the type of crude source of the bitumen, sometimes it has been observed that the above statement is incorrect. It may hence be mentioned that the bitumen may satisfy the penetration value, but may fail to satisfy the ductility requirements. Bitumen paving engineer would however want that both test requirements be satisfied in field jobs. Penetration or ductility can not in any case replace each other. The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread cracks. The test is conducted at 27 ± 0.5 ° Cand a rate of pull of 50 ± 2.5 mm per minute. The test has been standardized by the ISI.

Figure 4: Ductility test

- *Specific Gravity test:* The density of a bituminous binder is a fundamental property frequently used as an aid in classifying used in paving jobs. In most applications, the bitumen is weighted, but finally, in use with the aggregate system, the bitumen content is converted in volume basis. Thus an accurate density value is required for conversion of weight to volume. The specific gravity is greatly influenced by the chemical composition of the binder. Increased amounts of aromatic type compounds caused an increase in the specific gravity. The test procedure has been standardized by the ISI.

IV. Materials Used for Specimen

1. Bitumen
2. Sodium chloride.

V. Effect of Water on Bituminous Mixes

One of the complex problems in the field of highway engineering, existing since bitumen paving technology came into existence is stripping. The term stripping, as employed by highway engineers, denotes the occurrence of adhesion failure or weakening of the cohesive bonds within the aggregate asphalt system.It isconsidered as great economic loss and engineering failure regarding proper mixture design.

Majidzadeh.k (1969) stated that the factors affecting the adhesion failure phenomenon are innumerable. They include the material characteristics, construction techniques, and diversified environmental conditions. They are displacement, film rupture, and detachment and pore pressure theories. Of course, it is obvious that owing to the complexities of material composition and diversity of environmental conditions, no single mechanism may be adequate to explain the stripping phenomenon in bituminous mixtures. The concepts of the theories are briefly summarized as follows:

- *Displacement Concept:* According to this theory the binder aggregate function in the presence of water becomes thermodynamically unstable and reacts to more stable position [Lee,A.R] 1954. It is generally believed that, to displacement phenomena to be initiated in a mixture, the binder aggregate interface should become exposed to the water phase. That is well, the coated aggregate may not exhibit any binder displacement unless the continuity of aggregate coating is destroyed.
- *Detachment Concept:* The theory attributes the adhesion to a thermodynamic replacement of the bitumen by a thin film of water that may come from either outside or from within the aggregate while from the bitumen coating remains intact [Hughes, A.R]I 1960). The characteristics of the interface are believed to be very important in the detachment process. The water reaching the interface become intimately associated with the lattice of the mineral surface.
- *Pore Pressure Concept:* It has been postulated that the buildup of pore pressure in the mixture of high void content may result in stripping phenomena [Halberg, S] 1950. That is, on a wet surface of bituminous pavement additional forces due to traffic also act and these greatly exceed the thermodynamic forces. In a saturated pavement under dynamic load, water is pressed into the pavement in front of the moving load and sucked out behind the wheel contributing to the stripping phenomena. Among these four concepts, the displacement and detachment theories can be classified as the primary causes of stripping and pore pressure, film rupture concepts in fact only contributing to the phenomena.

VI. Effect of Mixture Density on Stripping

There are primarily three perquisites for the occurrence of stripping phenomena in bituminous mixtures: the presence of water in a pavement, repeated load application and the physiochemical nature of the bituminous aggregate system. To eliminate or reduce the chances of stripping, one should attempt at least one of these factors. From the pavement design point of view, the water present in the pavement can be reduced by decreasing the void content of the bituminous mixtures. This approach could be considered as one of the preventive measures in the construction of bituminous paving using the physio-chemically unstable bituminous aggregate system.111

VII. Preparation of Compressive Strength test Specimen

The mix proportion of cement fine aggregate and coarse aggregate is 1:2:4.The water-cement ratio is 0.50. Test for compressive strength is carried out on a cube. American Society for Testing Materials ASTM C39/C39M provides Standard Test. For cube test the types of specimen each cube 10cm X 10 cm x 10 cm is used. After 24 hours these molds are removed, and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. These specimens are tested by compression testing machine after three days, seven days curing or 28 days curing. Load at the failure divided by area of specimen gives the compressive strength of concrete.

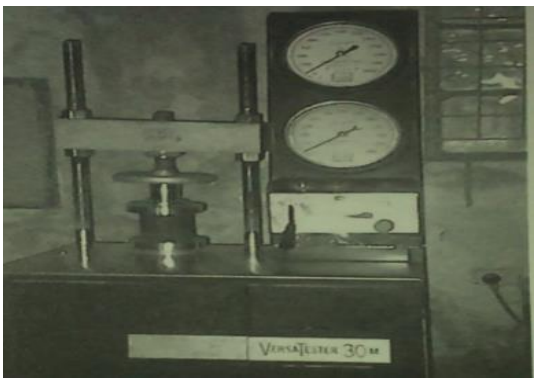


Figure 5: Experimental setup of compressive strength

VIII. Marshall Test Specimen

The coarse aggregates, fine aggregates and mineral should be proportioned and mixed specified gradation of mineral aggregates and bitumen binder as per IRG.29-1968. Approximately 1200g of aggregates and filler are taken and heated to a temperature of 170˚

C to 190 ° C. The compaction molds assembly, rammer, cleaned and kept pre-heated to temperature of 100 ° C to 145 ° C. The mixing temperature for 80/100 grade bitumen may be around 154 ° C that for 60/70 grade bitumen 160 ° C. The weight of aggregate taken may be suitably alerted a thickness of 63.5±3.0 mm

IX. Results and Discussions

a) *Effect of Salt on Properties of Bitumen*

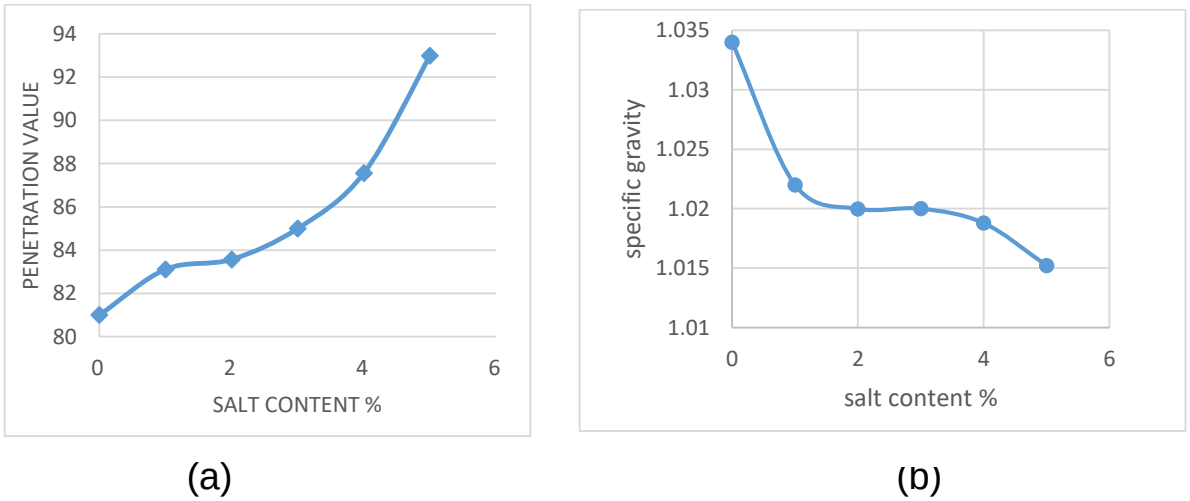


Figure 6: (a) variation of penetration value and (b) specific gravity concerning salt content.

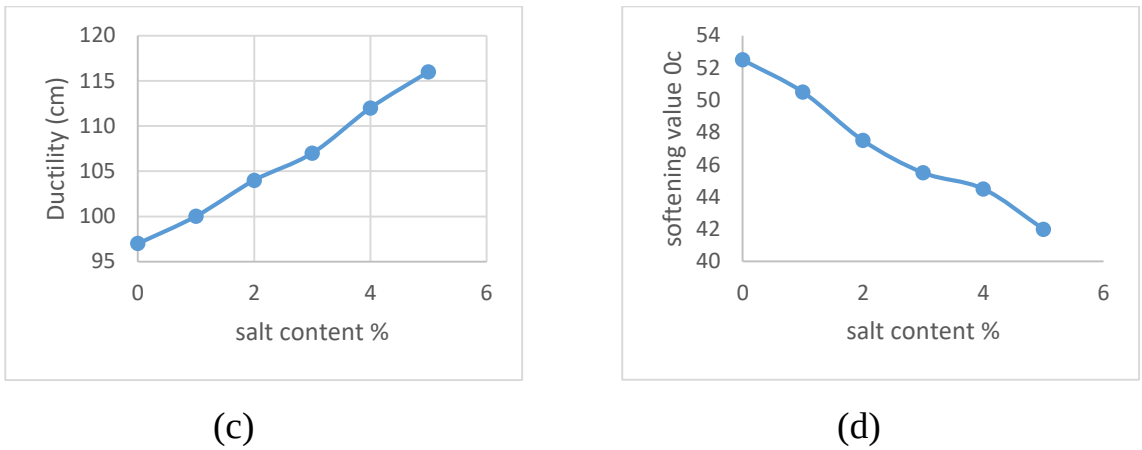
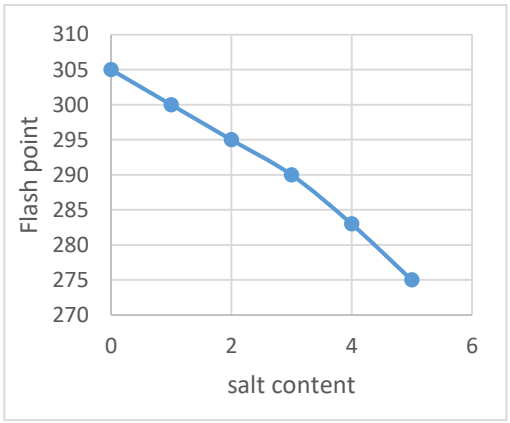
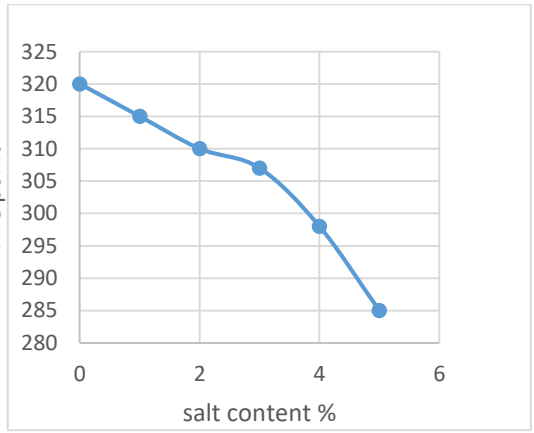


Figure 7: (c) variation of ductility and (d) softening value concerning salt content.



(e)



(f)

Figure 8: (e) variation of flash point value and (f) fire point value concerning salt content

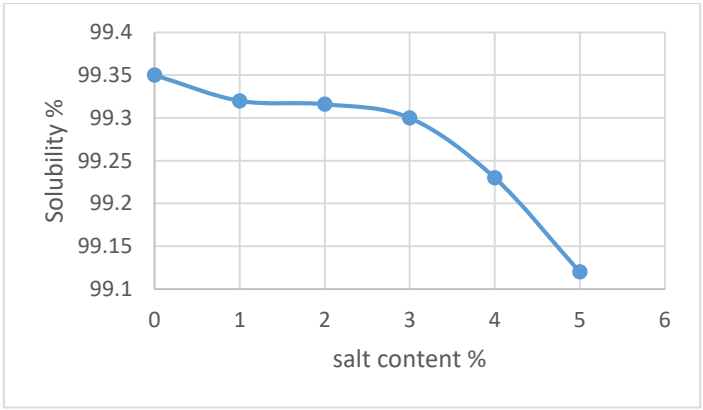
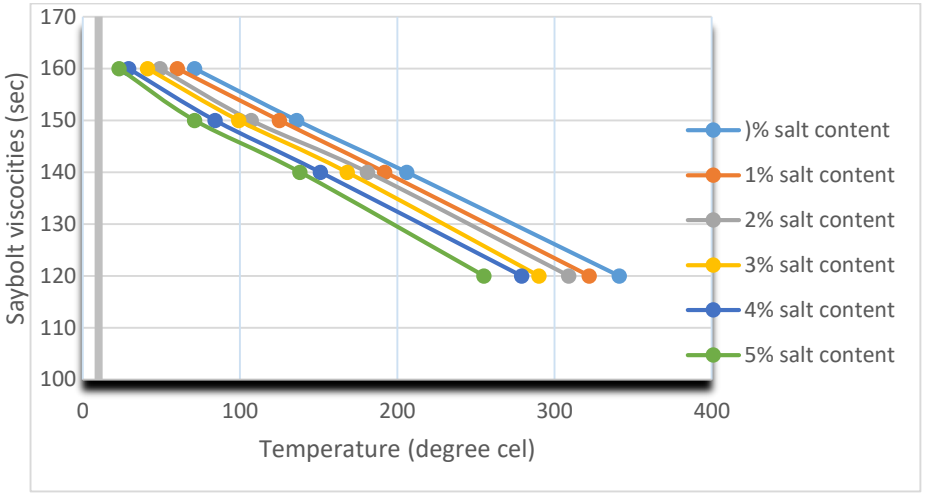
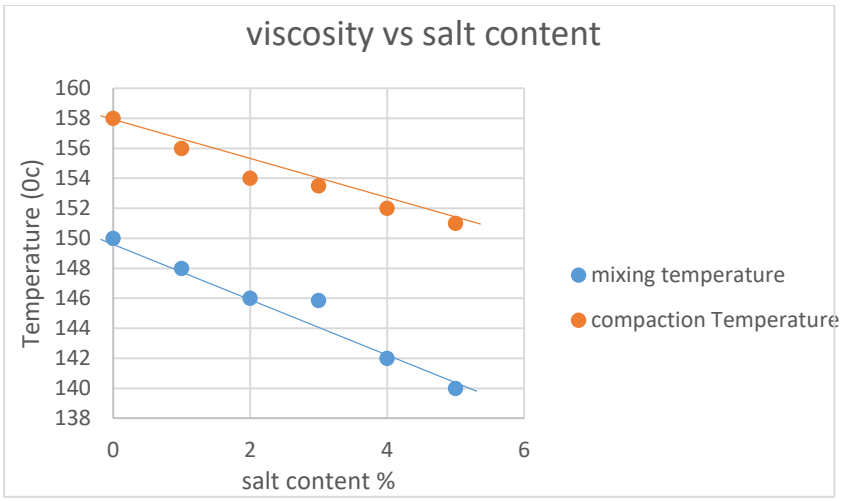


Figure 9: Variation of solubility concerning salt conten

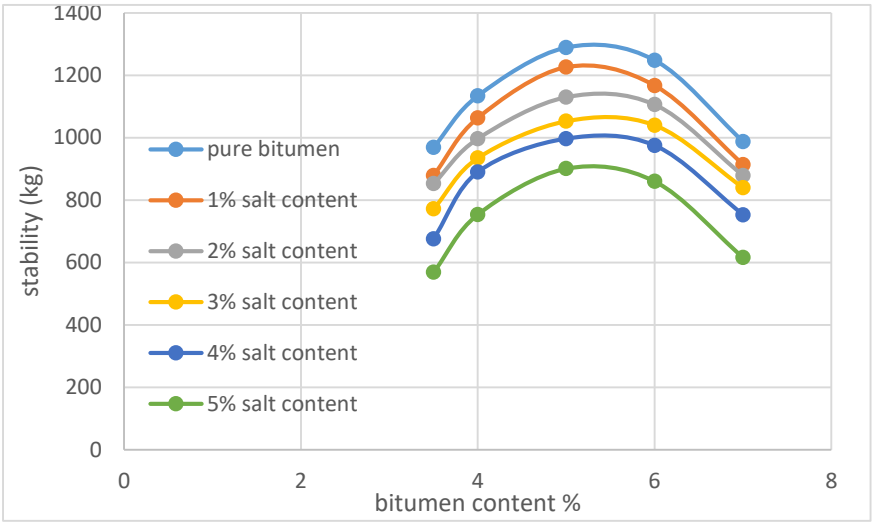
A Result of say bolt viscosities test of Bitumen



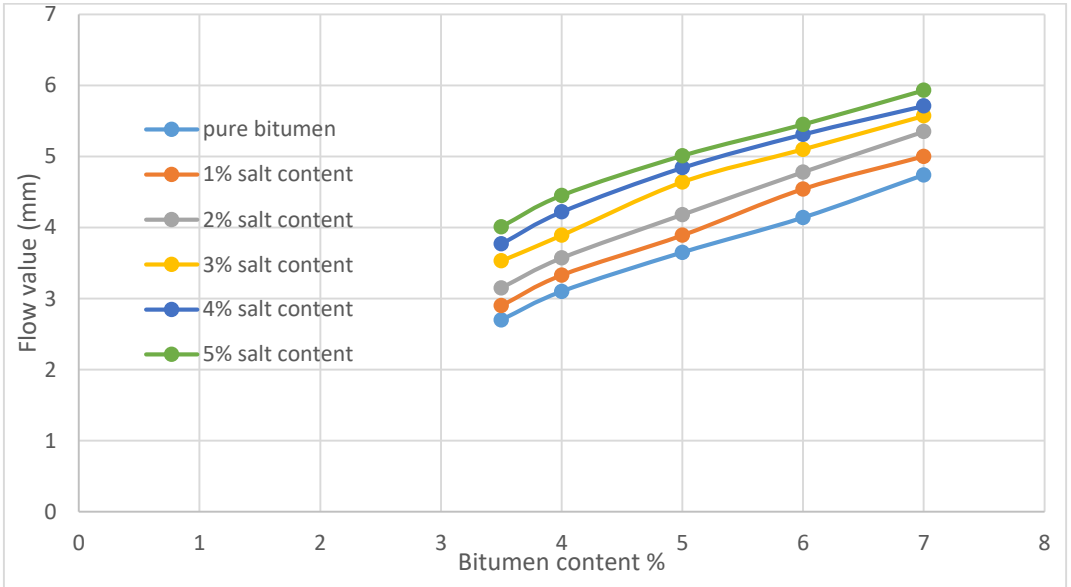
Viscosity of mixing and compaction temperature with salt content in binder bituminous mix



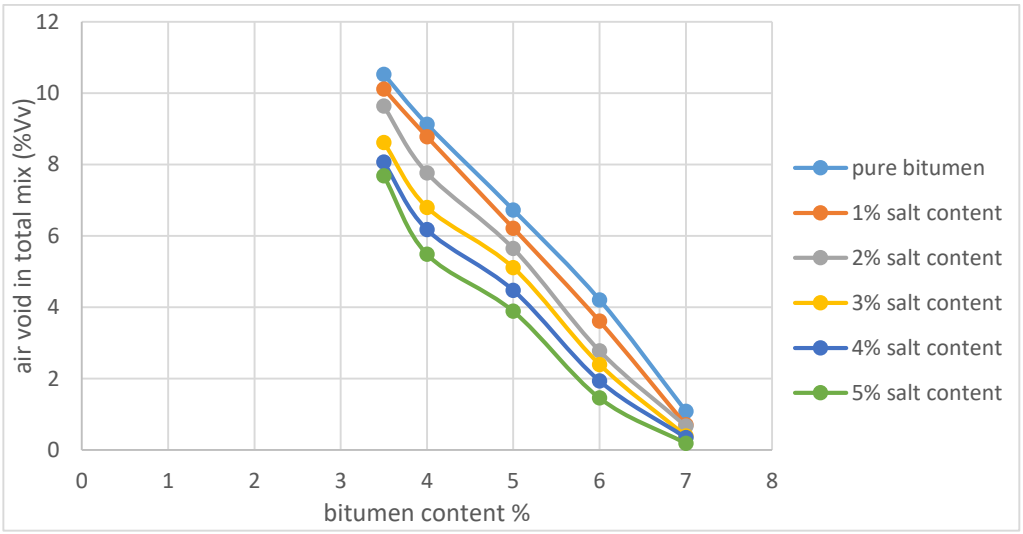
Variation of stability value concerning bitumen content



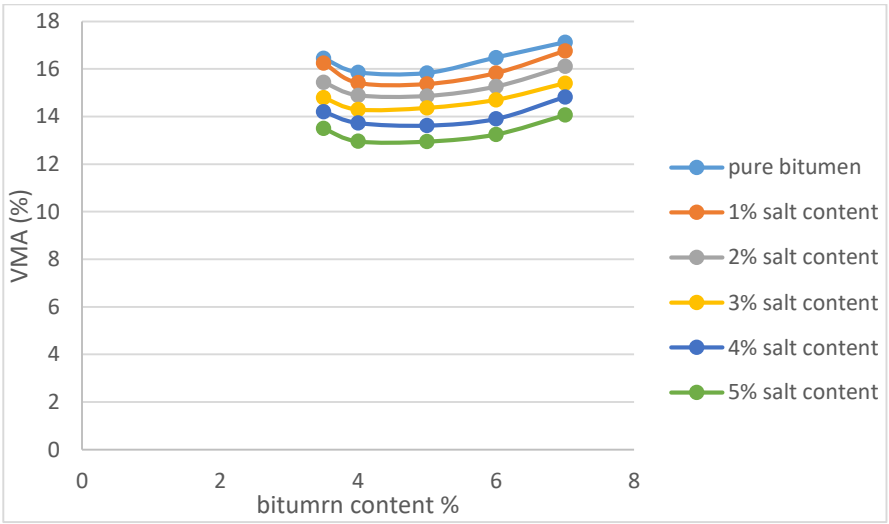
Variation of flow value concerning bitumen content percentage



Variation of percentage of total mix (Vv) concerning bitumen content percentage



Variation of percentage void of mineral aggregate with respect to bitumen content



X. Conclusion

Sodium chloride (Nacl) is a crucial factor for increasing the different properties of bitumen. But sometimes it has negative impacts as reducing the strength of bituminuous mixes. From the test values, it is clearly shown that, the penetration and ductility increases with the increases of salt content (percentage). On the other hand, flash, fire point, solubility decreases with increases of salt content. From the above graph, it is concluded that, tolerable limit of salt varying from 0% to 5%.

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Impact of Land use on Urban Storm Water Quality in Rajshahi City, Bangladesh

By Anupam Chowdhury, Protik Chakraborty & Tamanna Tanjum
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Abstract- Land use characteristics such as urban form, impervious cover significantly impact the water environments with increased runoff and the degradation of water quality. Hence, storm water management becomes a prime concern to safeguard the receiving water quality of the surrounding environment. The paper primarily concentrated to investigate the impact of land use characteristics on the variability of urban storm water quality in Rajshahi City, Bangladesh. Storm water runoff samples were collected from three different land use areas such as residential (Aloker Mor, New Market), commercial (Zero Point, Shaheb Bazar) and industrial (Bscic, Sapura) in Rajshahi City, Bangladesh. Collected storm water samples were tested in the laboratory to determine the physical (temperature, pH, turbidity, electric conductivity (EC)) and chemical parameters (total suspended solids (SS), biological oxygen demand (BOD)) using standard quality control and test methods specified in APHA 1999.

Keywords: storm water runoff, land use, storm water quality, rajshahi city.

GJRE-E Classification: FOR Code: 120504

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Anupam Chowdhury [α], Protik Chakraborty [σ] & Tamanna Tanjum [ρ]

Abstract- Land use characteristics such as urban form, impervious cover significantly impact the water environments with increased runoff and the degradation of water quality. Hence, storm water management becomes a prime concern to safeguard the receiving water quality of the surrounding environment. The paper primarily concentrated to investigate the impact of land use characteristics on the variability of urban storm water quality in Rajshahi City, Bangladesh. Storm water runoff samples were collected from three different land use areas such as residential (Aloker Mor, New Market), commercial (Zero Point, Shaheb Bazar) and industrial (Bscic, Sapura) in Rajshahi City, Bangladesh. Collected storm water samples were tested in the laboratory to determine the physical (temperature, pH, turbidity, electric conductivity (EC)) and chemical parameters (total suspended solids (SS), biological oxygen demand (BOD)) using standard quality control and test methods specified in APHA 1999. The test result shows that the residential storm water demonstrated the cleanest appearing with the lowest value of turbidity, suspended solids whereas the industrial had recorded the worst storm water quality comparing to others. On the other hand, BOD was found highest in commercial land use area. The study results will guide to storm water management of natural treatment systems for treating the storm water pollutants from specific land use.

Keywords: storm water runoff, land use, storm water quality, rajshahi city.

I. Introduction

The impact of urbanization is the important concern that significantly alters the catchment hydrology such as increase in peak flow, runoff volume and decreases the infiltration rate, runoff retention time and base flow. The quality of urban runoff in terms of the amount and types of pollutants generated and transported varies depending on land usage, and the activities carried out on the land (Arnold et al., 1996). Urban runoff quality and pollutants loading have been shown to have a high variability among different land use such as residential, industrial, commercial, agricultural, and land for the recreational purpose (Egodawatta et al., 2007). Rajshahi is one of the developing cities in Bangladesh and characterized by rapid urbanization. Large tracts of land are converted to residential, commercial and industrial developments (RCC Website, 2018). The study primarily concentrated to investigate the impact of land use characteristics on the variability of urban stormwater quality in Rajshahi City.

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II. Study Areas and Sample Collection

Rajshahi is the 4th largest among the eight divisions in Bangladesh that covered the area of 18,153.08 sq. Km (RCC Website, 2018). The study areas were selected at three different land uses such as residential, commercial and industrial in Rajshahi City Corporation as shown in Figure 1. The storm water sample was collected from three roads surface runoff such as Aloker Mor, New Market (site 1- residential), Bscic, Sapura (site 2- industrial) and Zero Point, Shaheb Bazar (site 3- commercial) in Rajshahi City (Figure 1). The details characteristics of these study areas are discussed below.

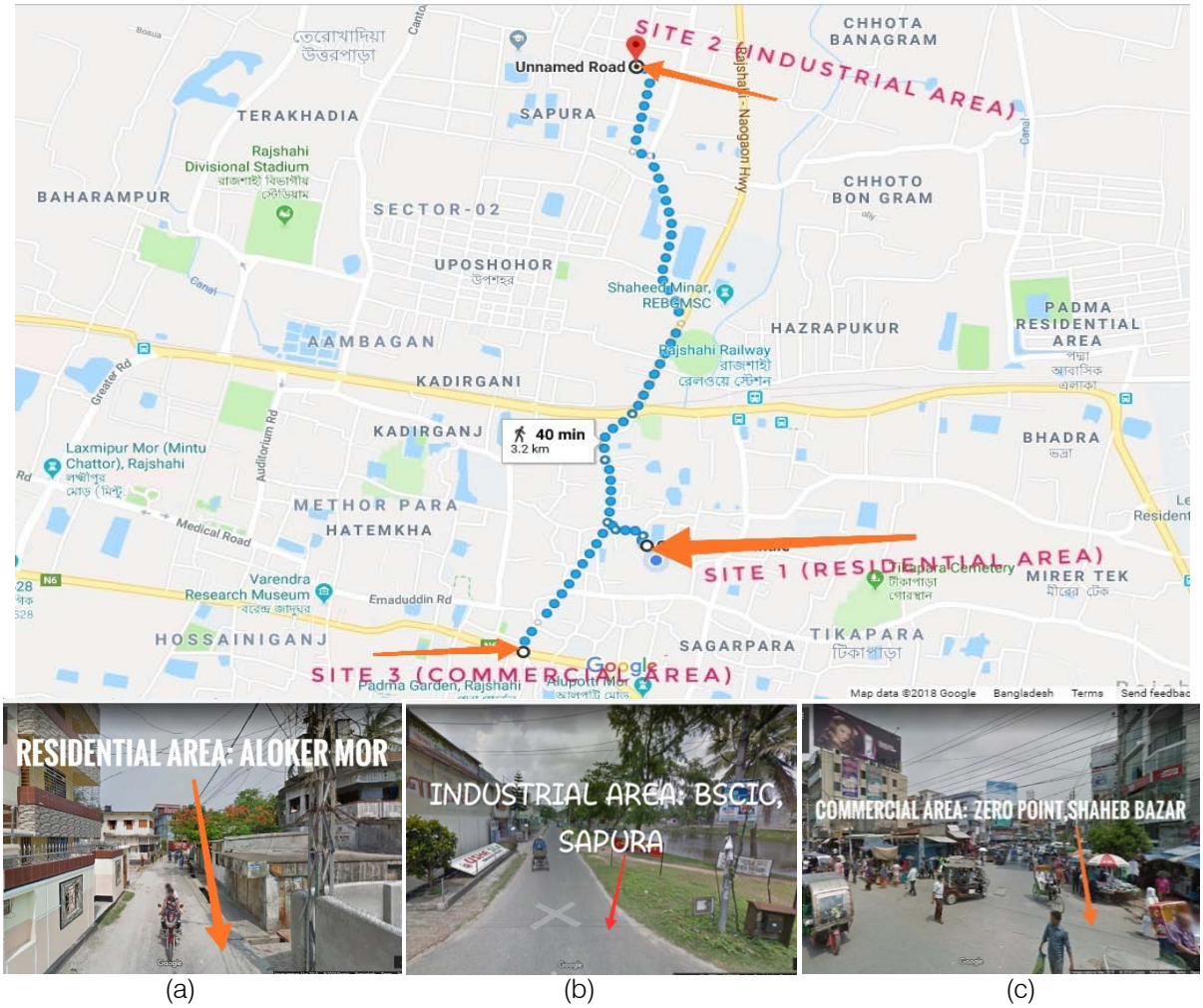
Site 1: Aloker Mor, New Market is an access road located in a typical suburban residential area with detached family houses (Figure 1a). The reason for choosing this site is typical urban form and road pattern. Most of the arterial roads are used by residents for convenient access. The pollutant availability on the road surface primarily depends on the periodic cleaning by street sweepers and light traffic.

Site 2: Even though Rajshahi has very limited industry so Bscic is one of the well known industries and situated in Sapura. Though Bscic industry is located along the road hence the site is selected as industrial area. A number of loading and unloading tasks is occurring everyday by heavy vehicle. Hence, the selected road surface was found highly eroded (Figure 1b).

Site 3: Zero Point, Shaheb Bazar is a crowded market area and is considered to be one of the busiest commercial areas in Rajshahi (Figure 1c). The traffic density is very high compared to other sites. The road surface condition of the place was found to be fair but with a coarse texture.

The sample collection was undertaken based on the standard procedure recommended by EPA, 1992. Sample was collected three times from one

location at different rainfall events to understand the effect of dry periods on the variability of stormwater quality. After sample collection, the bottle was properly sealed and leveled for future identification.



(a) (b) (c)

Figure 1: Location of study areas and sample collection points

III. Methodology

The collected samples were tested in the laboratory to determine the physical and chemical parameters using standard quality control and test methods specified in APHA 1999. The physical parameters include temperature, pH, turbidity, EC where chemical parameters are total suspended solids (SS), BOD. To investigate the relationship between land use characteristics and water quality, univariate techniques such as mean, median, standard deviation were applied.

a) Sample testing

The physical parameters such as temperature, pH, turbidity, EC were tested instant after collecting the sample. Then the chemical parameters were tested within 24 hours of collection. The sample testing was undertaken at the Environmental Engineering laboratory of Rajshahi University of Engineering and Technology. Standard quality control and test methods specified by APHA were followed to conduct the laboratory test (APHA, 1999).

b) Univariate and multivariate analysis tools

Mean:

The mean can be defined as the average of a numbers in a data set. Mean can be calculated from the ratio of the sum of data values to the total number of data points. The mathematical expression of the mean is shown in Equation (1).

$$\bar{X} = \frac{\sum x_n}{N} \quad (1)$$

Here, $\sum x_n$ = sum of data values.
N = total number of data points.
$\bar{X}$ = mean

Standard deviation (SD):

Standard deviation (SD) can be defined as the calculation of dispersion of a data set from its mean. SD also measures the variation in the distribution of a data set. This indicates that if the SD value is higher, the

variability or dispersion is higher and the deviation of the data point from its mean is also higher. The mathematical expression of the SD is shown in Equation (2).

$$\text{SD, } \sigma = \sqrt{\frac{\sum(x-\bar{X})^2}{N-1}} \quad (2)$$

Here, x= individual data points

$\bar{X}$=mean/average of the data points

N = total number of data points

σ= standard deviation

The coefficient of variation (CV):

The coefficient of variation (CV) can be defined as the ratio of the SD to the mean. If the CV value is higher, the dispersion level of the data points around the mean is higher. The CV is usually expressed as a percentage. An estimate can be considered more appropriate if the CV becomes lower. The mathematical expression of the CV is shown in Equation (3).

$$\text{CV} = \frac{\sigma}{\bar{X}} \quad (3)$$

Here, σ= Standard deviation.

$\bar{X}$=mean

IV. Results and Discussions

Table 1 shows a summary of the analysis results for selected stormwater quality parameters for each land use category. It can be seen that pollutants concentration vary considerably for each land use, which indicates that pollutant distribution throughout the catchment is highly dependent on land use. Suspended solids are one of the main indicators of water quality. Most of the pollutants absorbed by suspended solids and transport by storm water runoff (Ranjan and Shane, 2011).

Storm water in residential area demonstrated the cleanest appearing storm water with the lowest average amounts of suspended solids within the storm water. With a small variance for suspended solids and turbidity, residential sites are comparative clear among the other selected study areas.

The storm water quality in the industrial area was found highly polluted than other land use. This variation is due to the presence of the highest amounts of suspended solids and turbidity in the storm water runoff compared to the other land use. The industrial location also recorded a higher BOD value than the residential sites. This variation is due to the presence of organic matter in industrial waste and distributed by traffic and wind.

Commercial storm water resulted in containing low concentrations of suspended solids and turbidity value than industrial sites. However, the highest BOD value is recorded in commercial area than other sites. This is because commercial area produces the highest organic wastes that decomposed on road surfaces and wash-off by storm water runoff.

Table 1: Average pollutant loading for each specified land use

Land use type	pH			TURBIDITY (NTU)			EC (mg/L)			SUSPENDED SOLIDS (mg/L)			BOD (mg/L)		
	MEAN	SD	CV (%)	MEAN	SD	CV (%)	MEAN	SD	CV (%)	MEAN	SD	CV (%)	MEAN	SD	CV (%)
Residential	6.90	0.18	1.95	10.00	0.38	3.58	1066.67	115.47	10.82	115.73	10.84	9.39	2.22	0.04	1.82
Commercial	6.57	0.10	1.64	8.52	0.13	1.54	1433.33	57.74	4.02	189.99	4.30	2.26	8.23	0.25	3.06
Industrial	6.42	0.05	0.80	13.17	0.90	6.85	1533.33	57.72	3.76	394.45	4.32	1.09	3.17	0.28	9.11

Table 2: Comparison of study results with EPA guideline

Water Quality Parameters	Study Results			EPA Guidelines (EPA, 2001)
	Residential	Commercial	Industrial	
pH	6.90	6.57	6.42	5.5-8.5
Turbidity	10.0	8.52	13.17	1-50 NTU
Conductivity	1066.67	1433.33	1533.33	1000-2500 mg/L
Suspended Solids	115.73	189.99	394.45	100 – 400 mg/L
BOD	2.22	8.23	3.17	< 20 mg/L

The average concentrations of pH, Turbidity, Conductivity, SS, BOD in each land use area and the EPA standard guideline value for storm water are shown in Table 2. Table 2 shows that the highest pH value was also an acceptable level of EPA guidelines (Table 2). Study result shows the highest BOD value of 8.23 in the commercial area is also an acceptable limit of less than found 6.90 in residential area, lowest is 6.42 at the industrial site which complies with the EPA guidelines as 5.5-8.5 for storm water. The EC, turbidity, suspended solids was found highest in the industrial area which is 20 mg/L recommended by EPA.

The average pollutant concentrations for three different land uses are shown in Figure 1 to 5.

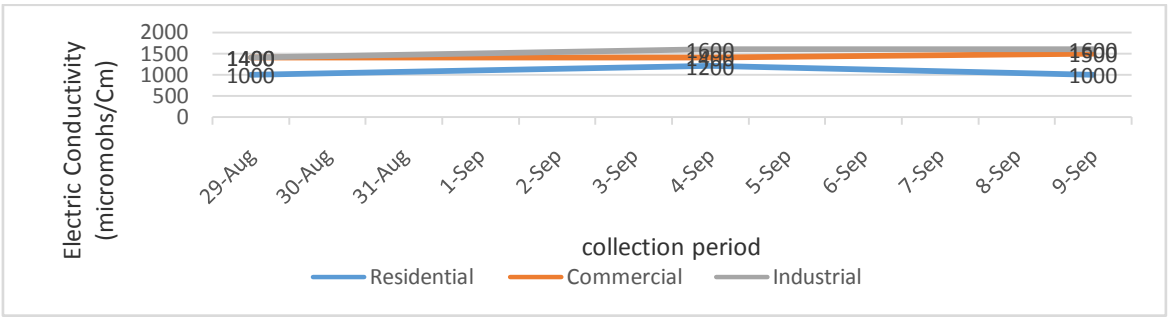


Figure 1: Variation of conductivity value in three different land uses

The variation of EC is shown in Figure 1. As seen in Figure 1, industrial area has a higher EC than others. This variation can be due to the reaction of chemical or metal substances with the water flowing from the runoff area. Residential area has a lower value compared to others because there is no reaction of chemical or metal substances.

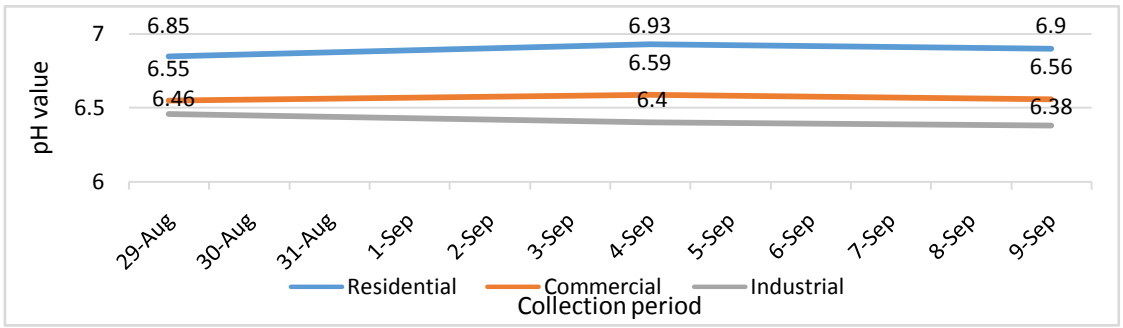


Figure 2: Variation of pH value in three different land uses

As shown in Figure 2, pH value was found similar for both industrial and commercial areas. This variation can be due to the presence of chemical and metal that reacts with water and decrease the pH value. In contrast, higher pH was found for the residential area due to the decomposition of organic substances such as plant leaves, vegetation, etc.

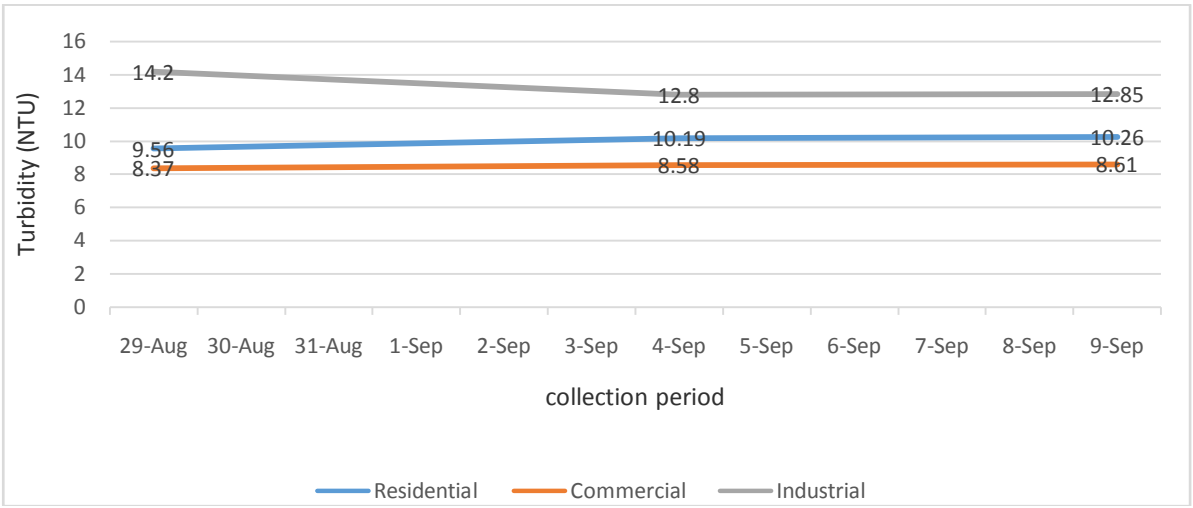


Figure 3: Variation of turbidity value in three different land uses

Variation of turbidity for different land use is shown in Figure 3. When the very fine solid particles remains suspended in water then turbidity are formedthat further prevents the light penetration and unbalance the aquatic ecosystem. As seen in Figure 3, the highest turbidity was found in the industrial area. This can be due to the presence of fine particles from different production processes and distributed on the

road surface by traffic, wind, workers during loading and unloading time.

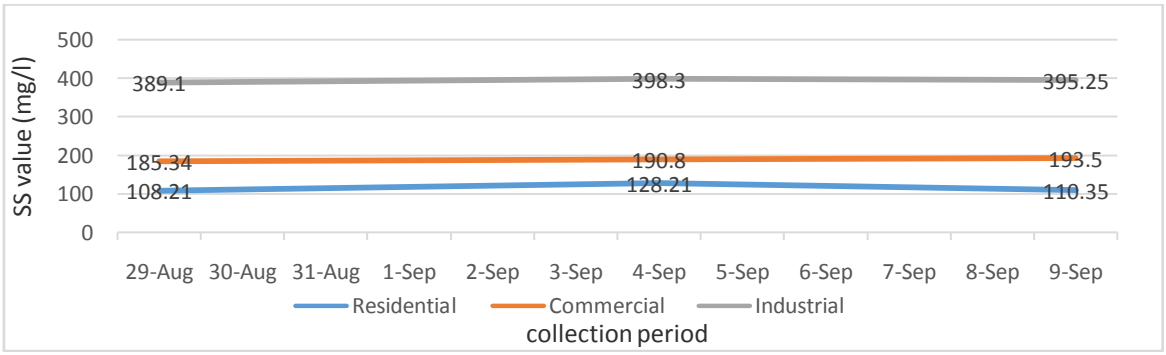


Figure 4: Variation of suspended solids in three different land uses

The variation of suspended solids (SS) is shown in Figure 4. As seen in Figure 4, the residential area has a lower SS value compared to other land uses in the study area. This variation can be due to the periodic cleaning of road surfaces by street sweepers. It can be seen that the average concentration of SS in industrial areas was almost two and a half times the values for residential areas. The commercial and industrial area produces a high level of SS. This is due to the high population density, traffic density and various anthropogenic activities occur by human and distribute by traffic and wind.

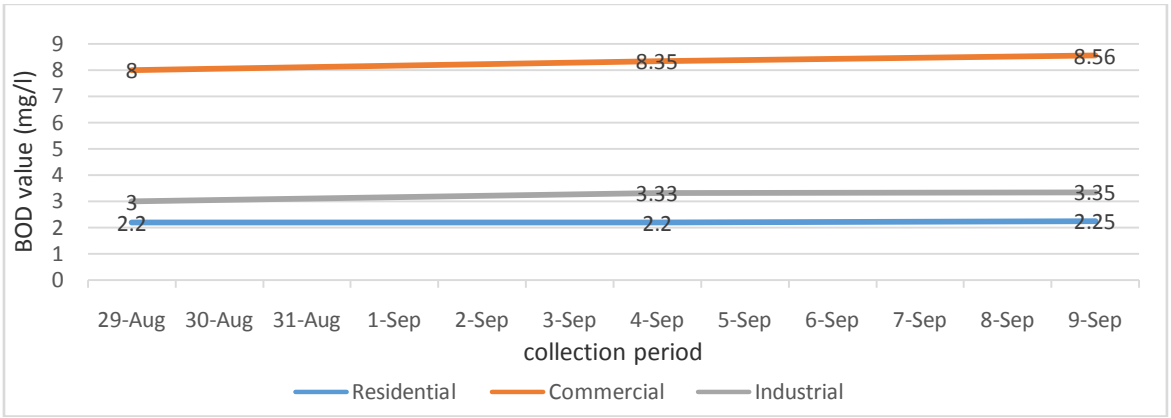


Figure 5: Variation of BOD value in three different land uses

Variation of BOD value is shown in Figure 5. As seen in Figure 5, the residential area has a lower BOD compared to industrial and commercial areas. As we know, BOD value measures the amount of dissolve oxygen to biologically decompose organic matters. The presence of organic matter is higher in the commercial area that produces from local fruit seller, decomposed fruit bunch and vegetable waste. In contrast, residential area produces a small amount of organic waste that's why the value is lowest among the others.

V. Conclusions

To understand the impacts of land use pattern on storm water quality, storm water samples have been tested in three land use areas; residential, commercial, industrial lands in Rajshahi city. The results show very interesting patterns. Turbidity value was found comparatively higher in the industrial area than other land use. Excessive use of chemical, industrial production, heavy use of machine increases the value of water quality parameters such as turbidity, EC in industrial area. The highest BOD value was recorded in the commercial land. The industrial storm water had the dirtiest appearing storm water quality showing the highest amounts of suspended solids. Residential storm water shows the lowest concentrations of pollutants with higher pH value.

The study results will provide a clear idea about storm water pollutants generating from commercial, industrial and residential areas. Also this study will guide to the storm water management authority for development of natural treatment systems for treating the stormwater pollutants for specific land uses to safeguard the receiving water quality and aquatic ecosystem.

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Fatigue Strain based Approach for Damage Evolution Model of Concrete

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Abstract- Fatigue Strain-based Approach to the Damage evolution Modeling plays a very important role in the evaluation of the material properties of concrete utilizing strain analysis methods, the nonlinear fatigue strain evolution model is proposed, evolution model of fatigue modulus is established and the hypothesis of fatigue modulus inversely related fatigue strain amplitude causes formation of cracks and microcracks, anisotropic in nature, damage the chemistry and orientation of composed structural elements of concrete materials resulting reduction in stiffness and inelastic deformations. This paper presents Fatigue Strain and Damage evolution Model of concrete, developed, in strain life approach, by using damage principle of continuum thermodynamics. Due to the formation of nucleation and microcracks by continuous fatigue loading and unloading result in stiffness reduction and inelastic deformation, and hence the phenomenon is termed as damaged.

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GJRE-E Classification: FOR Code: 090599

Strictly as per the compliance and regulations of:

Fatigue Strain based Approach for Damage Evolution Model of Concrete

Indra Narayan Yadav [α] & Dr. Kamal Bahadur Thapa [σ]

Abstract- Fatigue Strain-based Approach to the Damage evolution Modeling plays a very important role in the evaluation of the material properties of concrete utilizing strain analysis methods, the nonlinear fatigue strain evolution model is proposed, evolution model of fatigue modulus is established and the hypothesis of fatigue modulus inversely related fatigue strain amplitude causes formation of cracks and microcracks, anisotropic in nature, damage the chemistry and orientation of composed structural elements of concrete materials resulting reduction in stiffness and inelastic deformations. This paper presents Fatigue Strain and Damage evolution Model of concrete, developed, in strain life approach, by using damage principle of continuum thermodynamics. Due to the formation of nucleation and microcracks by continuous fatigue loading and unloading result in stiffness reduction and inelastic deformation, and hence the phenomenon is termed as damaged. The fatigue strain, fatigue modulus evolution curves have three stages, namely, variation phase, linear change stage, and convergence stage. The difference in both curves is that fatigue strain curves have S-shaped from lower left to upper right corner but the fatigue modulus curve has reverse in direction i.e. fatigue strain is inversely related to fatigue modulus. Damage is analyzed by using fourth-order stiffness tensor consisting damage parameter utilizing by the consistency equation associated with the cycle to the failure of the prescribed surface in strain life. The model regarding fatigue strain, fatigue modulus, damage parameter, mechanisms for stiffness degradation, inelastic deformations is well discussed and validated by experimental results.

Keywords: fatigue strain based approach; damage; evolution model; concrete fatigue modulus; thermodynamics; fatigue modulus; inelastic, strength reduction.

I. Introduction

In recent times, concrete has become the bedrock of infrastructural civilization in the world. Statistics have shown that over 75% of the infrastructures in the world have to do with concrete. Therefore, it is necessary to study regarding the behavior of concrete in every aspect from the production, transportation, placing and eventually maintenance of concrete.

Concrete today has a very wide range of applications. Virtually every civil engineering work in Nepal today is directly or indirectly involving the use of concrete. The use of concrete in civil engineering works includes: construction of residential houses, industrial warehouses, roads pavement construction, Shore Protection works, piles, domes, bridges, culverts, drainages, canals, dams etc. (Shetty, 2005; Neville, 2011; Edward and David, 2009; Duggal, 2009; Gambhir, 2005). In recent practice, the cases of failure of structures and roads (concretely related failure) occur on a yearly basis.

Variation of material internal as well as external deformation of concrete materials due to fatigue loading to the failure is reflected by fatigue strain. For, qualitative understanding of the failure fatigue strain, the detailed study of the evolution curve is essential. Longitudinal and residual deformations in three stage namely rapid, stable and ultimate growth stage which is generally used in all types of concrete as well as all types of fatigue failure i.e. compression, tension, bending, uniaxial, biaxial or multiaxial fatigue (Chen. Et. Al), which is in the form of cubical polynomial fitting curve, resulting in the correlation coefficients is more than 0.937. According to Cachim et. Al., in a constant order of magnitude, the stress in the different level of concrete have different coefficients used in logarithmic form regarding the curve obtained from the maximum strain versus the number of cycles graph at the second phases of concrete. The linear nature of curve obtained from graphs regarding maximum strain versus the number of cycles to the failure according to Xie. Et. Al. who had also given the well-developed experienced formula for fatigue strain in second phases of the concrete matrix. Data regarding fatigue strain in a similar stage was nonlinear in nature given by Wang et. Al.

At the low accuracy, three staged fatigue evolution equations are described in a simpler way in different literature. Strictly speaking, it became complicated to develop nonlinear equations of high precision based on the relation between fatigue strain and the number of cycles at different amplitude. At low fatigue stress with the comparison to the ultimate stress of concrete material but greater than ultimate value, very few research has been done yet. Without considering the initial strain, for three-stage fatigue strain and curve regarding strain to the number of cycles to the failure is obtained which caused alter fittings of curves coefficient fittings parameters. Therefore endurance limit for concrete is not guaranteed according to Miner's hypothesis [1].

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For the production of concrete, except cement, all materials are locally available i.e. sand, aggregate, and water. So, it is very much popular in the list of construction material is construction engineering. Concrete is a heterogeneous matrix related to the composition i.e. cement, sand, aggregate and water among them cement is the weakest part compared to the remaining ingredients. At the initial stage of production, water and air are inside the matrix of the composition of structure slowly released from that matrix during an initial setting time to final setting time creating microvoids at the original place of air and water made alteration of the chemistry of the matrix. When the cyclic load which is lower than ultimate load but higher than threshold limit is applied to the concrete then due to alteration i.e. separation of the matrix in composition, alters the ingredient from each other by creating microvoids continuously increasing up to microvoids and finally break up which is called fracture. Force applied until fracture appears is usually lesser than ultimate monotonic loads phenomenon which deals about the chemistry of fracture is called fatigue mainly caused by progressive cyclic loading tends to change the [2] permanent internal structure resulting microcracks until macrocracks creating the permanent damage in the concrete matrix.

Based on the concept of dual nature of fatigue damage, the model for ordinary concrete has been documented through the number of investigations presented in the different researches. It is very much essential to predict the progressive creep damage model based on cyclic dependent and time-dependent damage at constant and variable amplitude. [3] Damage in the concrete pavement was carried out through the accelerated pavement testing results. As per Minor hypothesis, one cannot predict the cumulative fatigue damage in concrete accurately. The theoretical model for the prediction of cumulative fatigue model in compression, compression-tension, tension-tension, flexural, torsional, uniaxial, bi-axial, tri-axial under monotonic and cyclic loading using different approaches such as bounding surface approach with using the energy released rate by constructing damage effective tensor poorly described in different past research papers and articles also. The need for validation of such models in inelastic flow and microcracking related to plasticity theories and voids caused degradation of elastic moduli through energy dissipations. The experimental work of [4] described that the increase of damage in the concrete material takes place is about last 20% of its probable fatigue life. [5] Presented a theoretical model to describe the fatigue process of concrete material in alternate tension-compression fatigue loading utilizing double bounding surface approach with strain-energy release rate by evaluating damage-effective tensor. A number of damage constitutive models regarding failure fatigue life of concrete have been published for capturing the model regarding mechanical behavior of concrete under monotonic and cyclic loading ([6], [7], [8], [9], and [10]), which have done in the past.

This paper presents the physical meanings, the ranges, and the impact on the shape of the curve of parameters in the nonlinear strain evolution model are all discussed. The evolution model of fatigue modulus was established under constant amplitude bending fatigue loading based on the fatigue strain evolution model and the hypothesis of fatigue modulus inversely related fatigue strain amplitude. A class of damage mechanics theory to model the fatigue damage and failure of concrete caused by the multitude of cracks and microcracks whereby anisotropic damaging behavior is captured through the use of proper response function involving damage parameter in material stiffness tensor is also developed. The increment of damage parameter is obtained from consistency equation in cycle dependent damage surface in strain space. The model is also capable of capturing the inelastic deformations that may arise due to misfits of crack surfaces and development of sizable crack tip process zone. Moreover, the whole process is validated by the experimental data

II. Formulation

According to the continuum damage mechanics approach to describe the constitutive relation for the concrete matrix relate to fatigue loading at low frequency by neglecting thermal effects. Considering, the isothermal process, small deformations and rate independent behavior, the Helmholtz Free Energy (HFE) per unit volume can be written from [1] is given below :

$$\mathrm{A}(\boldsymbol{\varepsilon}, \mathrm{k}) = \tfrac{1}{2}\boldsymbol{\varepsilon} : \mathbf{E}(k) : \boldsymbol{\varepsilon} - \dot{\boldsymbol{\sigma}}^{\mathbf{i}} : \boldsymbol{\varepsilon} + \mathrm{A}^{\mathrm{i}}(k) \tag{1}$$

Where, $\mathbf{E}$ (k) = fourth-order elastic stiffness tensor, $\boldsymbol{\varepsilon}$ = strain tensor, $\boldsymbol{\sigma}^{\mathbf{i}}$ = stress tensor. $A^{i}(k)$= surface energy of microcracks [2], and k = cumulative fatigue damage parameter. The colon (:) indicates the tensor contraction operation.

For inelastic fatigue damage, a constitutive relation between the fatigue stress and fatigue strain tensors shall be established by fourth order material's stiffness tensor such as

$$\boldsymbol{\sigma} = \frac{\partial A}{\partial \boldsymbol{\varepsilon}} = \mathbf{E}(k) : \boldsymbol{\varepsilon} - \boldsymbol{\sigma}^{i}(k) \tag{2}$$

The rate of change of Eqn (2) with respect to cyclic number N is given by

$$\dot{\boldsymbol{\sigma}} = \mathbf{E}(k) : \dot{\boldsymbol{\varepsilon}} + \dot{\mathbf{E}}(k) : \boldsymbol{\varepsilon} - \dot{\boldsymbol{\sigma}}^{i}(k) = \dot{\boldsymbol{\sigma}}^{\mathbf{e}} + \dot{\boldsymbol{\sigma}}^{\mathbf{D}}(k) + \dot{\boldsymbol{\sigma}}^{\mathbf{i}}(k) \quad (3)$$

Where $\dot{\boldsymbol{\sigma}}^{\mathbf{e}}$, = stress increment, $\dot{\boldsymbol{\sigma}}^{\mathbf{D}}$ = rate of stress-relaxation, and $\dot{\boldsymbol{\sigma}}^{\mathbf{i}}(k)$ = rate of stress tensor

For small deformation, the following matrix of the fourth-order stiffness tensor, E, when adopted

$$\frac{\partial^2 A}{\partial \boldsymbol{\varepsilon} \partial \boldsymbol{\varepsilon}} = \mathbf{E}(k) = \mathbf{E}^{\mathbf{0}} + \mathbf{E}^{\mathbf{D}}(k) \quad (4)$$

Where $\mathbf{E}^{\mathbf{0}}$ = Initial stiffness before fatigue loading and $\mathbf{E}^{\mathbf{D}}(k)$ = overall stiffness degradation during fatigue loadings. Further, $\dot{\mathbf{E}}(k)$ and $\dot{\boldsymbol{\sigma}}^{\mathbf{i}}(k)$ = fluxes in the thermodynamic state sense and are expressed in terms of fatigue evolutionary equations as

$$\dot{\mathbf{E}}^{\mathbf{D}} = -\dot{\mathrm{k}}\mathbf{L} \quad \text{and} \quad \dot{\boldsymbol{\sigma}}^{i} = \dot{\mathrm{k}}\mathbf{M} \quad (5)$$

Where L and M are, fourth and second-order response tensors which determine the directions of the elastic and inelastic fatigue damage processes. Following the Clausius- Duhem inequality equations, applying the standard thermodynamic discussions [13] and a potential function by assuming unloading is in an elastic process

$$\Psi(\boldsymbol{\varepsilon}, k) = \tfrac{1}{2}\boldsymbol{\varepsilon} : \mathbf{L} : \boldsymbol{\varepsilon} - \mathbf{M} : \boldsymbol{\varepsilon} - \tfrac{1}{2} p^2(\boldsymbol{\varepsilon}, k) = 0 \quad (6)$$

In Eqn (6), $p(\boldsymbol{\varepsilon}, k)$ = damage function which is given as

$$p^2(\boldsymbol{\varepsilon}, k) = 2\left[h^2(\boldsymbol{\varepsilon}, k) + \frac{\partial A^i}{\partial k} \right] \quad (7)$$

Which is for some scalar-valued function $h^2(\boldsymbol{\varepsilon}, k)$. It should be noted that as long as the function $p^2(\boldsymbol{\varepsilon}, k)$ is well defined, the right-hand side of Eqn (7) need not be identified.

For specific forms of response tensors, L and M shall be specified. Since fatigue damage is highly directional, so, directionality response tensors should be developed. For the development of response tensor, the strain tensor is divided into positive and negative cones. The positive and negative cones of the fatigue strain tensor completely hold the corresponding positive and negative eigenvalue of the system, i.e., $\boldsymbol{\varepsilon} = \boldsymbol{\varepsilon}^{+} + \boldsymbol{\varepsilon}^{-}$ as positive and negative cones of the strain tensor, respectively. Based on the fact of experimental observations for concrete materials, the damage is assumed to arrive in the cleavage mode of cracking as per Figure1.

Damage function p(k) is obtained from an experimental test of uniaxial tensile loading, then the equation can be written as

$$\mathrm{p}(k) = \varepsilon_{\mathrm{u}} ln\left(\frac{\mathrm{E}^0}{\mathrm{E}^0 - \mathrm{k}} \right) \quad (11)$$

When, $\beta = 0$in the inelastic damage surface, the limit damage surface reduces to

$$\mathrm{p}(k) = \varepsilon_{\mathrm{u}} \quad (12)$$

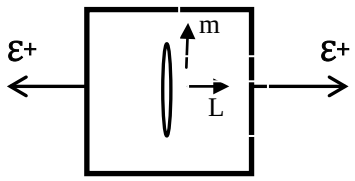

Figure 1: Crack Opening and Tensile Mode I damage

For the mode of cleavage cracking, the terms of response tensors are postulated for L and M

$$\mathbf{L} = \frac{\boldsymbol{\varepsilon}^{+} \otimes \boldsymbol{\varepsilon}^{+}}{\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}} \quad (8)$$

$$\mathbf{M} = \beta \boldsymbol{\varepsilon}^{+} \quad (9)$$

Substituting the response tensors L and M from Eqns (8) and (9) into Eqn (6) gives the final form of the fatigue cracked damaged surface

$$\Psi(\ , k) = \tfrac{1}{2}\ : \frac{\boldsymbol{\varepsilon}^{+} \otimes \boldsymbol{\varepsilon}^{+}}{\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}} : \boldsymbol{\varepsilon} - \ \boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon} - \tfrac{1}{2} p^2(\boldsymbol{\varepsilon}, k) = 0 \quad \ldots.(10a)$$

The equation of damage surface for uniaxial tensile loading Eqns (10a) is rewritten as

$$\Psi(\boldsymbol{\varepsilon}, k) = \tfrac{1}{2}\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+} - \beta \boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+} - \tfrac{1}{2} p^2\ (\boldsymbol{\varepsilon} k, \ ) = 0$$

$$= \tfrac{1}{2}\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}(1 - 2\beta) - \tfrac{1}{2} p^2(\boldsymbol{\varepsilon}, k) = 0 \quad (10b)$$

Where ε_{u} = strain corresponding to the uniaxial tensile strength of concrete,

For describing the three-stage fatigue damage law, we have

$$\varepsilon^{n} = \varepsilon^{0} + \propto \left(\frac{\beta}{\beta - \frac{n}{Nf}} - 1 \right)^{1/p} \quad (13)$$

Where, $\boldsymbol{\varepsilon^0}$ = initial strain and $\boldsymbol{\varepsilon^n}$ = fatigue strain, $\boldsymbol{n}$ = cycle times of fatigue loads. $\boldsymbol{N_f}$ = fatigue in life. $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, and $\boldsymbol{p}$ were the parameter regarding fatigue.

III. Fatigue Damage Model

In fact, progressive permanent structural changes in the form of cracks due to fatigue loading flows material fails at lower stress than the ultimate tensile strength of the material which has a higher value than the threshold limit. Damage surface of the material within the given prescribed strain, fatigue loading (reloading and unloading process) increases the growth of microcracks which leads inelastic deformation tends to reduce the ultimate overall strength of the concrete material. Therefore, for modified damage surface, fatigue damage with respect to the number of cycles i.e. $\Psi(\boldsymbol{\varepsilon}, k)$ is obtained from

$$\tfrac{1}{2}\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}(1-2\beta)X(N) - \tfrac{1}{2}p^{2}(\boldsymbol{\varepsilon}, k) = 0 \qquad (14)$$

Where, X (N) = function that depends on the number of loading cycles. Propose a power function for X (N) as

$$X(N) = N^{A} \qquad (15)$$

Here, N = number of loading cycles, and A = material parameter. From, Eqns (11) and (14), we can obtain the cumulative fatigue parameter k as under

$$k = E^{0}\left[1 - \frac{1}{exp\left(\frac{\sqrt{(1-2\beta)N^{A}\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}}}{\varepsilon_{u}}\right)}\right] \qquad (16)$$

Differentiating Eqns (15) with respect to N, an increment of damage in one cycle can be obtained as

$$\dot{k} = \frac{dk}{dN}$$

$$= \frac{AN^{\frac{A}{2}-1}E^{0}\sqrt{\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}(1-2\beta)}}{2\varepsilon_{u}exp(-\sqrt{\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}(1-2\beta)N^{A}/\varepsilon_{u}^{2}})} \qquad (17)$$

Finally, the rate of damage parameter $\dot{k}$ can be used in the simple constitutive relation in Eqn (14) for uniaxial tensile stress state to get inelastic deformation, stiffness reduction and strength reduction due to fatigue cycles to the failure. Substituting all related parameters, we can get,

$$\dot{\boldsymbol{\sigma}} = \mathbf{E}(k) : \dot{\boldsymbol{\varepsilon}} - \dot{k}\left(\frac{\boldsymbol{\varepsilon}^{+} \otimes \boldsymbol{\varepsilon}^{+}}{\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}} : \boldsymbol{\varepsilon} + \beta\boldsymbol{\varepsilon}^{+}\right) \qquad (18)$$

When $\beta = 0$Eqn (17) can be treated for uniaxial tension-tension fatigue loading then the process is classified as elastic-damaging, in which stress-strain curve returns to original conditions upon unloading of the material. In fact, damage incurred in concrete shall not be considered perfectly elastic. The tired unloaded material shows some residual strains due to the development of sizable crack tip process zone at the surface and misfits of the crack surfaces.

At the condition of uniaxial tension, Eqn (18) can be written as

$$\dot{\boldsymbol{\sigma}} = \mathbf{E} : \dot{\boldsymbol{\varepsilon}} - \left[\frac{AN^{\frac{A}{2}-1}E^{0}\sqrt{\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}\eta}\left((1+\beta)\right)}{2\varepsilon_{u}exp\left(-\sqrt{\frac{\boldsymbol{\varepsilon}^{+} : \boldsymbol{\varepsilon}^{+}\eta N^{A}}{\varepsilon_{u}^{2}}}\right)}\right]\boldsymbol{\varepsilon}^{+} \qquad (19)$$

Where, $\eta = 1 - 2\beta$

IV. Fatigue Strain Evolution Model

Depending upon the different stress types, three-stage variation law of fatigue evolution model was proposed. Moreover, some valuable physical parameters like initial strain, instability speed of the third stage as a form of acceleration directly proportional to the total fatigue life of concrete. Mathematically, the model could be obtained as below.

$$\boldsymbol{\varepsilon^{n}} = \boldsymbol{\varepsilon^{0}} + \propto \left(\frac{\beta}{\beta - \frac{n}{N_f}} - \mathbf{1}\right)^{1/p} \qquad (20)$$

In formula (20), $\boldsymbol{\varepsilon^{0}}$ = initial strain and $\boldsymbol{\varepsilon^{n}}$ = atigue strain, $\boldsymbol{n}$ = cycle times of fatigue loads, $\boldsymbol{N_f}$ = fatigue life. $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, and $\boldsymbol{p}$ were damage parameters.

If $\boldsymbol{\varepsilon^{n}_{max}}$ or $\boldsymbol{\varepsilon^{n}_{res}}$ was interpreted in the form of $\boldsymbol{\varepsilon^{n}}$, formula (20) can be modified. if the initial maximum strain $\boldsymbol{\varepsilon^{0}_{max}}$ or initial residual strain $\boldsymbol{\varepsilon^{0}_{res}}$ is regarded as the value of $\boldsymbol{\varepsilon^{0}}$, formula (21 and 22) should be obtained.

$$\boldsymbol{\varepsilon^{n}_{max}} = \boldsymbol{\varepsilon^{0}_{max}} + \propto \left(\frac{\beta}{\beta - \frac{n}{N_f}} - \mathbf{1}\right)^{1/p} \qquad (21)$$

$$\boldsymbol{\varepsilon^{n}_{res}} = \boldsymbol{\varepsilon^{0}_{res}} + \propto \left(\frac{\beta}{\beta - \frac{n}{N_f}} - \mathbf{1}\right)^{1/p} \qquad (22)$$

Equation (21) is a formula for maximum strain and equation (22) is the formula for the residual strain.

On the basis of the elastic proportional limit, if the upper limit of fatigue stress is large then fatigue strain increases fastly. The slope of the curve regarding this increment will be large and became vertical that causes the degeneration of the three-stage curve. When the upper limit of fatigue does not exceed the threshold

value, the elastic strain should be added to the initial strain and value became unchanged, shows similarity in curve formulation. By the experiment, it can be shown that the value of most stresses falls in between the value of threshold and upper limit.

Being the maximum and minimum value of stress and strain in fatigue test, two types of the curve regarding maximum strain i.e. ε^0_{max} and residual strain i.e. ε^0_{res} with respect to the cyclic number are obtained. The main causes for obtaining these two types of the curve are due to defects in materials and preloading conditions also. It is very much difficult to differentiate these two maximum and residual value, so experiment regarding fatigue test is essential.

Therefore, at that condition of fatigue loading reaches to the upper limit then, the corresponding maximum strain ε^1_{max} and residual strain ε^1_{res} are obtained and adopted in this paper. For comparison, strain obtained the formula of ε^1_{max} and ε^1_{res} compared to the actual experimental data i.e. $\varepsilon^1_{res} = 0.25(\varepsilon^1_{max}/\varepsilon_{unstable})^2$. In this formula, $\varepsilon_{unstable}$ is a total strain of concrete in an unstable state.

For the study of fatigue strain parameters α, β and p, on the basis of evolution law of fatigue strain curves, divided by fatigue strain in both side of formulas (21) and (22), we get

$$\frac{\varepsilon^n_{max}}{\varepsilon^f_{max}} = \frac{\varepsilon^0_{max}}{\varepsilon^f_{max}} + \frac{\propto}{\varepsilon^f_{max}} \cdot \left(\frac{\beta}{\beta - \frac{n}{N_f}} - 1\right)^{1/p} \quad (23)$$

$$\frac{\varepsilon^n_{res}}{\varepsilon^f_{res}} = \frac{\varepsilon^0_{res}}{\varepsilon^f_{res}} + \frac{\propto}{\varepsilon^f_{res}} \cdot \left(\frac{\beta}{\beta - \frac{n}{N_f}} - 1\right)^{1/p} \quad (24)$$

Formula (23) and (24) are the normalized fatigue strain evolution model. Where, εf_{max} = limited maximum fatigue strain and $\varepsilon\ f_{res}$ = limited fatigue residual strain.

β = destabilizing factor the value of which depends on p and α. If n/N_f (Circulation ratio) is equal to 1, the coordinate point (1, 1) will be adopted in formulas (23) and (24), thus obtained the values of β as formula (25) and 26, which is the maximum fatigue strain and the residual fatigue strain.

$$\beta_1 = \left(\frac{\left(1 - \frac{\varepsilon^0_{max}}{\varepsilon^f_{max}}\right)}{\left(\frac{\propto}{\varepsilon^f_{max}}\right)}\right)^{-p} + 1 \quad (25)$$

$$\beta_2 = \left(\frac{\left(1 - \frac{\varepsilon^0_{res}}{\varepsilon^f_{res}}\right)}{\left(\frac{\propto}{\varepsilon^f_{res}}\right)}\right)^{-p} + 1 \quad (26)$$

From equation (23) impacts of p and α on the fatigue, strain evolution curve can be calculated. Firstly, the impact of p was analyzed i.e. $\varepsilon^0_{max}/\varepsilon f_{max}$ and $\alpha/\varepsilon f_{max}$. After that, combined with p and $\varepsilon^0_{max}/\varepsilon f_{max}$, the impact of α was further calculated. The curve regarding the impact of p and α were shown in Figures.

It is obviously shown that according to the rate of convergence speed of p, influences the convergence speed of curve in S nonlinear model. The third stage of the curve will grow faster when the faster increment of P which is also called instability speed factor. Therefore the factor p should be located in the curve.

The parameter α values on the curve shall also affect the curve in the sense of total fatigue life of the material which shall be shown in the third stage of the nonlinear curve. After increasing of α, the part of acceleration shall become shorter. $\alpha/\varepsilon f_{max}$ is located corresponding to $(0,\ 1-\varepsilon^0_{max}/\varepsilon f_{max})$, whereas, α was placed in the comparison of $(0,\ \varepsilon f_{max}-\varepsilon^0_{max})$. The obtained value of the parameters α, β and ρ are mainly aimed which is found in b-type curves having three stages of evolutions. Therefore, it can be imagined that the values for both type curve are not limited by the literature. By modeling, S-shaped curves contents various parameters including different kinds of fatigue strain evolutions at the different stages for the concrete material.

V. Numerical Examples

The proposed model contains two material parameters, first is A which is a factor related to materials intermolecular microcracks and the second one is β which is called damage factor related to kinematic phenomena of the particle i.e. crack surface close perfectly after unloading. Damage parameter i.e. k, indicates the reduction in stiffness, is obtained by measuring stiffness at different three stages of the fatigue loading cycle. The kinematic parameter, β, is obtained by obtaining the permanent deformation during one of the fatigue cyclic loadings. Due to the scarcity of reliable experimental data from the different researches for obtaining the fatigue damage parameters in performing numerical simulation, analyst's judgments to obtain numerical results. Table (1) analysis for fatigue curve regarding stiffness, cumulative damage parameter versus the number of cycles, Table (2) analysis for fatigue curve regarding maximum stress versus the number of cycles, Table (3) Maximum Stress predicted by Peiyin Lu. Et. Al 2004 through experiment, Table (4) Fatigue Damage predicted by Peiyin Lu. Et. Al 2004 through experiment, Table (5) Fatigue Strain Evolution Model, Influence of Strain parameter "p", Table (6) Fatigue Strain Evolution Model, Influence of Strain parameter "α", Table (7) Iteration calculation table for finding out the best value of strain parameter "β", Table (8) Analysis for S-shaped family of fatigue strain curve, all Table from (1) to (8) are prescribed in this paper for sample calculation which gives the clear idea of fatigue strain behaviour.

The model formulation for obtaining modulus reduction with an increment at t the number of fatigue

and (7) shows the decrease of maximum stress level (S-N curve) in cyclic tension-tension loading, Figure (8) model prediction for maximum stress level regarding fatigue damage parameter i.e. A=0.10 and β=0.00, Figure (9) model prediction for maximum stress level regarding fatigue damage parameter i.e. A=0.10 and β=0.15, Figure (10) and (11) on other hand, shows corresponding experimental result regarding decrease in stiffness is shown in Figure (2) and (3). Figure (6) of materials stress and increase of cumulative fatigue damage parameter with respect to increase of number of cyclic loading, Figure (12) Concrete Fatigue Strain Evolution, Influence of Fatigue Strain Parameter "ρ", Figure (13) Concrete Fatigue Strain Evolution, Influence of Fatigue Strain Parameter "$\propto$", Figure (14) Concrete Fatigue Strain Evolution, "Family Strain Curve" . Finally, the model captures the relevant features of the cyclic response.

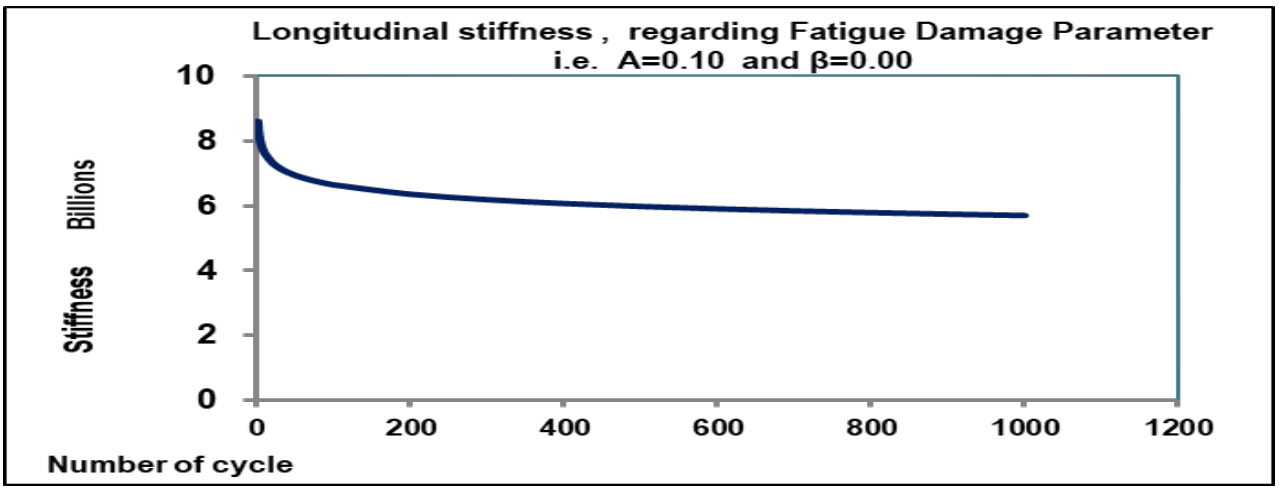

Figure 2: Formulation of Model against stiffness reduction with the number of cyclic loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.00$

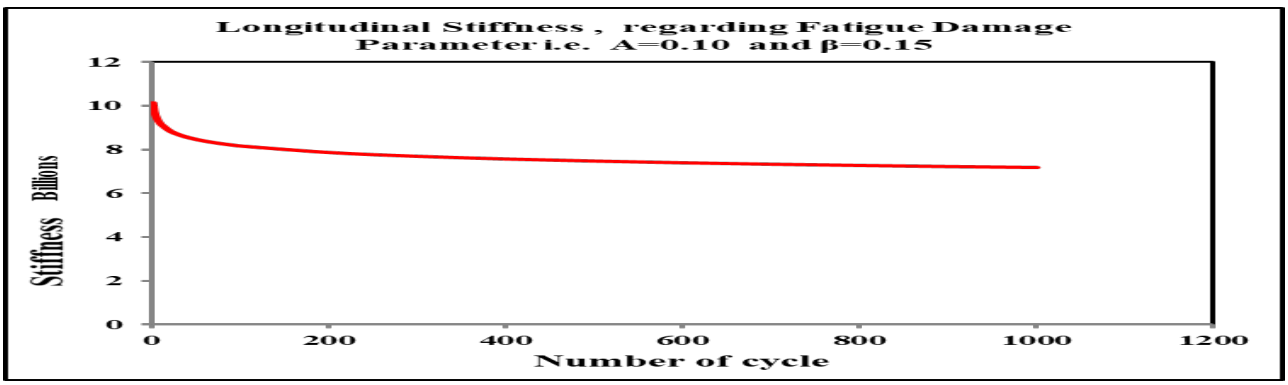

Figure 3. Formulation of Model against stiffness reduction with the number of cyclic loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.15$

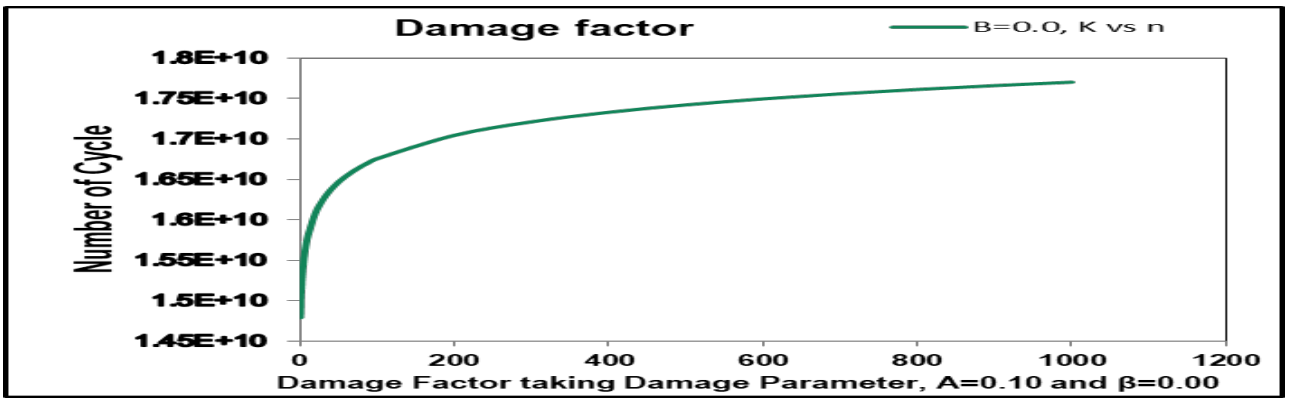

Figure 4: Model prediction of Damage Factor with the number of cyclic loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.00$

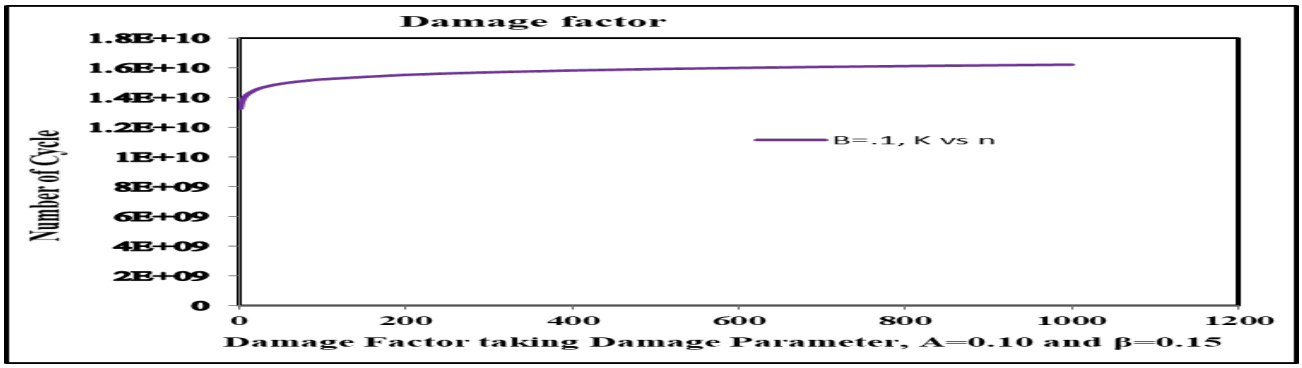

Figure 5: Model prediction of Damage Factor with the number of cyclic loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.15$

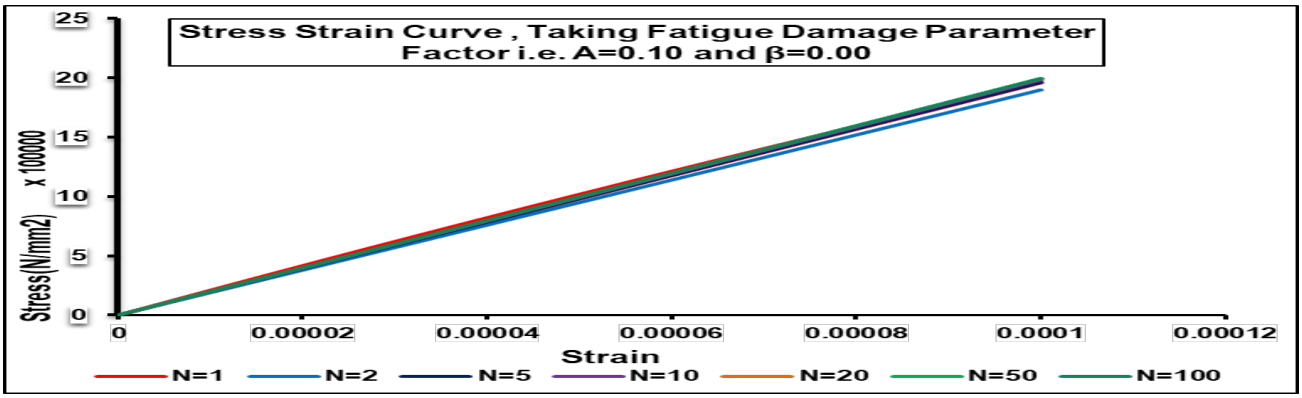

Figure 6: Cyclic stress-strain behavior of concrete during elastic damaging process theoretically under uniaxial fatigue loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.00$

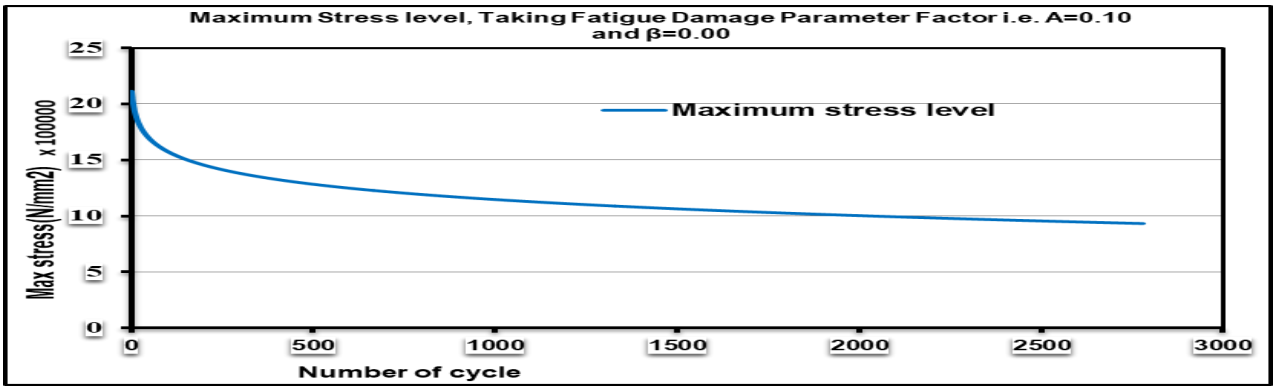

Figure 7: Theoretical cyclic stress-strain behavior of concrete during elastic damaging process under uniaxial fatigue loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.15$

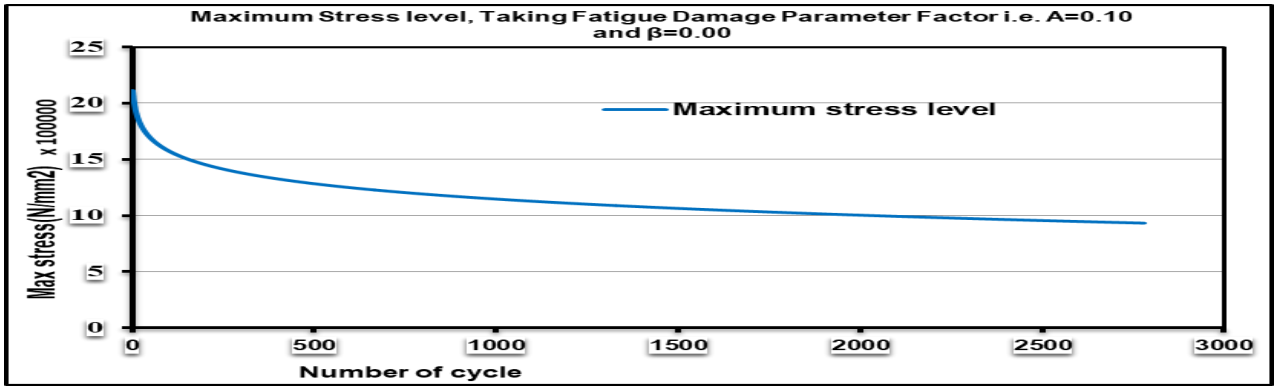

Figure 8: Model prediction of Maximum Stress Level versus Number of Cycle under uniaxial fatigue loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.00$

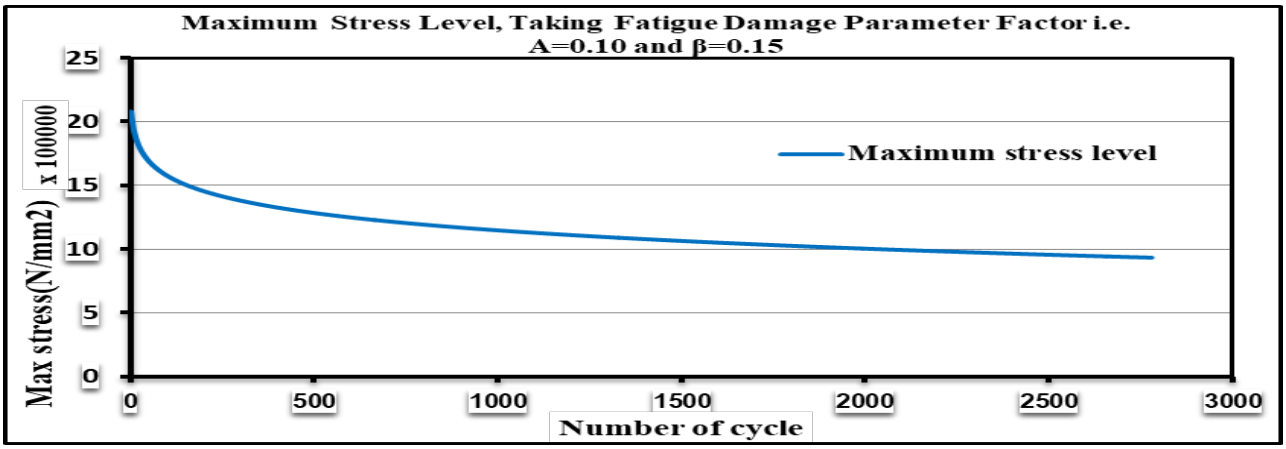

Figure 9: Model prediction of Maximum Stress Level versus Number of Cycle under uniaxial fatigue loading. Adopting the Value of Fatigue Damage Parameter, A=0.10 and $\beta = 0.15$

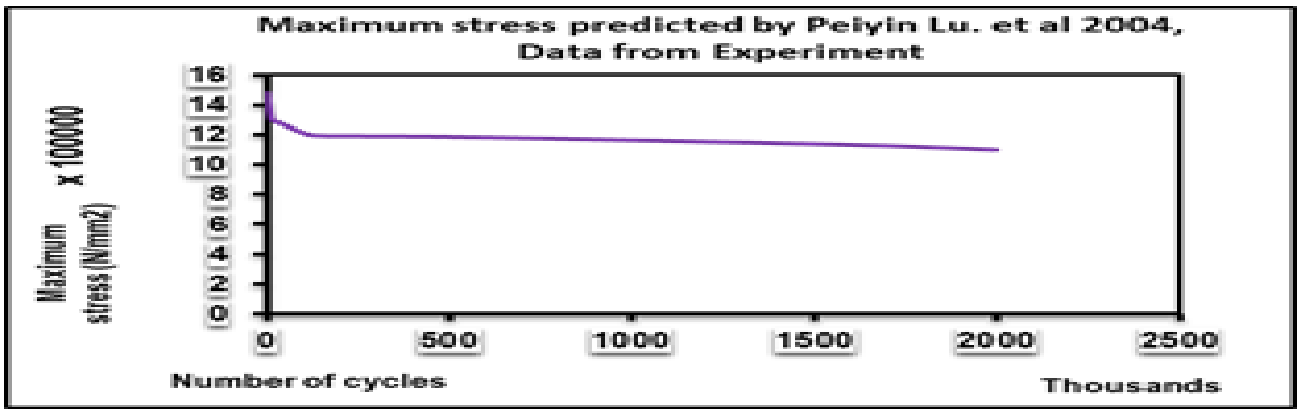

Figure 10: Model of maximum stress level during cyclic tension. Enhancement of the theory, *Figure 8 and 9 by Peiyin Lu. Et. Al 2004*

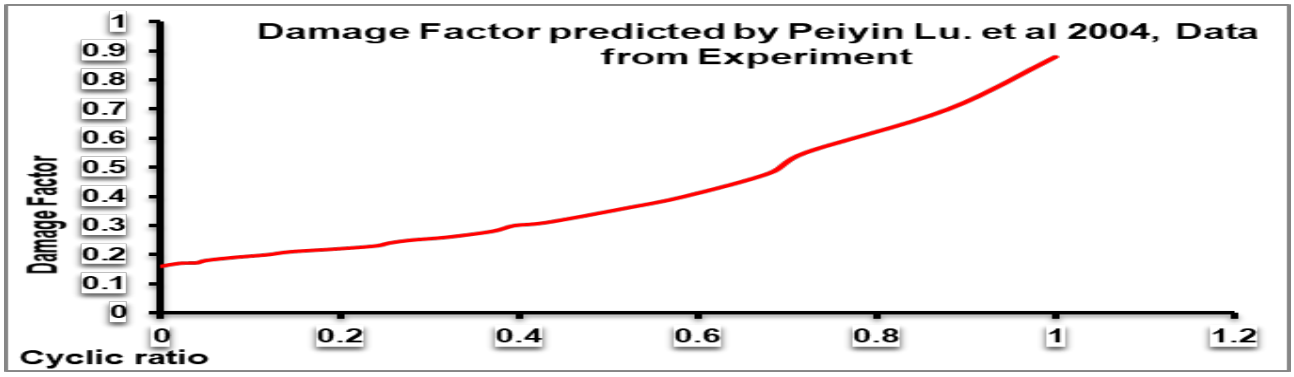

Figure 11: Damage variation with the number of cyclic loading. Prediction of the theory, *Figure (4) and Figure (5). Experimental Figure [11], by Peiyin Lu. Et. Al 2004*

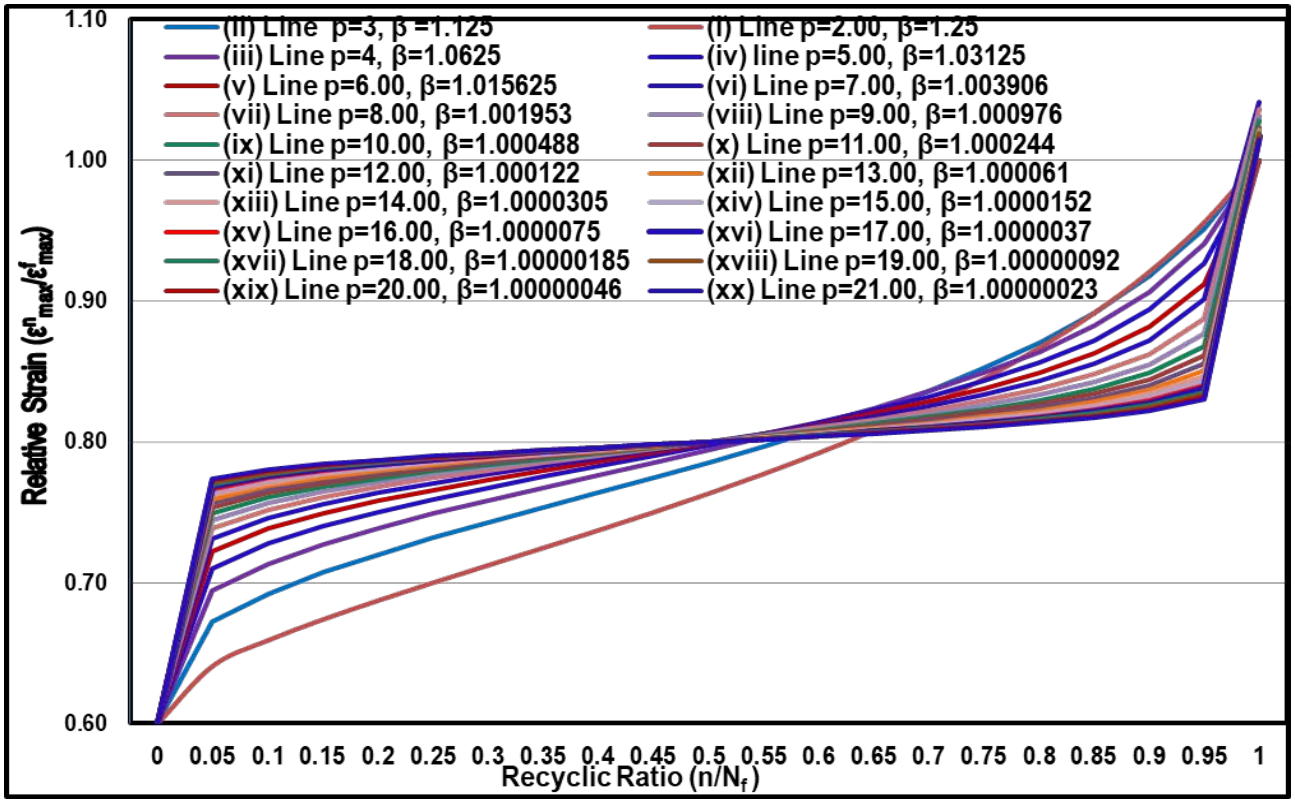

Figure 12: Concrete Fatigue Strain Evolution, Influence of Fatigue Strain Parameter "*p*" on Fatigue Strain Curve by Putting the value of (i) p=2.00, β=1.25 (ii) p=3.00, β=1.125 (iii) p=4.00, β=1.0625 (iv) p=5.00, β=1.0315 (v) p=6.00, β=1.015625 (vi) p=7.00, β=1.003906 (vii) p=8.00, β=1.001953 (viii) p=9.00, β=1.000976 (ix) p=10.00, β=1.000488 (x) p=11.00, β=1.000244 (xi) p=12.00, β=1.000122 (xii) p=13.00, β=1.000061 (xiii) p=14.00, β=1.0000305 (xiv) p=15.00, β=1.0000152 (xv) p=16.00, β=1.0000075 (xvi) p=17.00, β=1.0000037 (xvii) p=18.00, β=1.00000185 (xviii) p=19.00, β=1.00000092 (xix) p=20.00, β=1.00000046 (xx) p=21.00, β=1.00000023 and $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.60 and $\propto/\varepsilon^f_{max}$=0.20

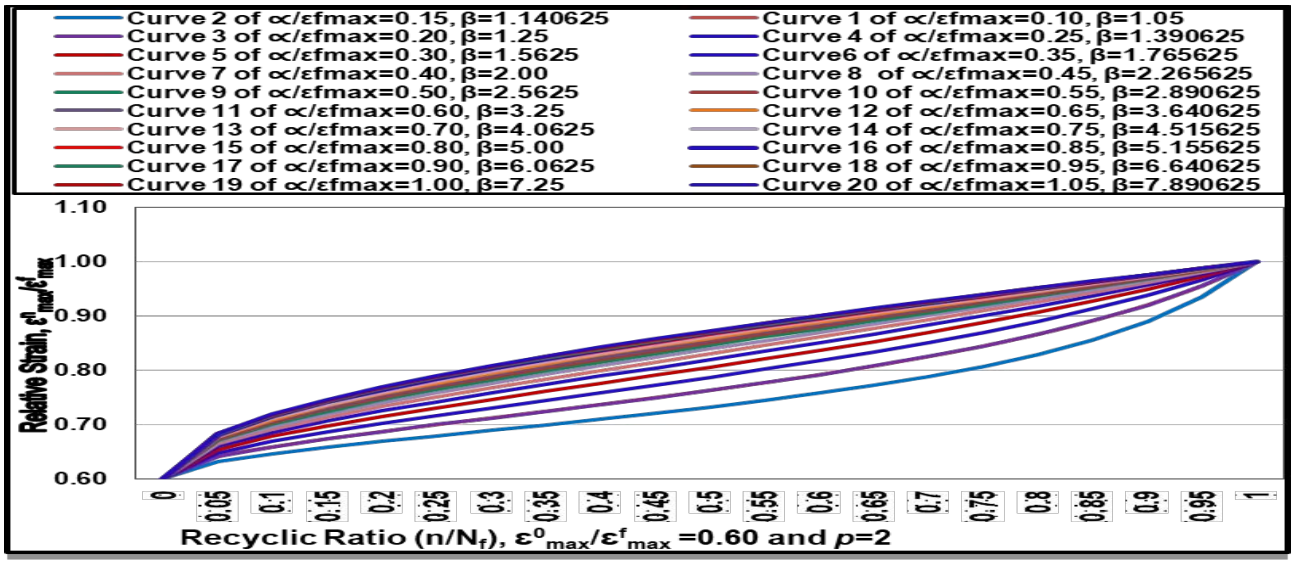

Figure 13: Concrete Fatigue Strain Evolution, Influence of Fatigue Strain Parameter "∝" on Fatigue Strain Curve, Putting the value of (i) $\propto/\varepsilon^f_{max}$=0.10 to 1.05, β=1.05 to 7.890625 and $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.60, p=2 constant in all cases.

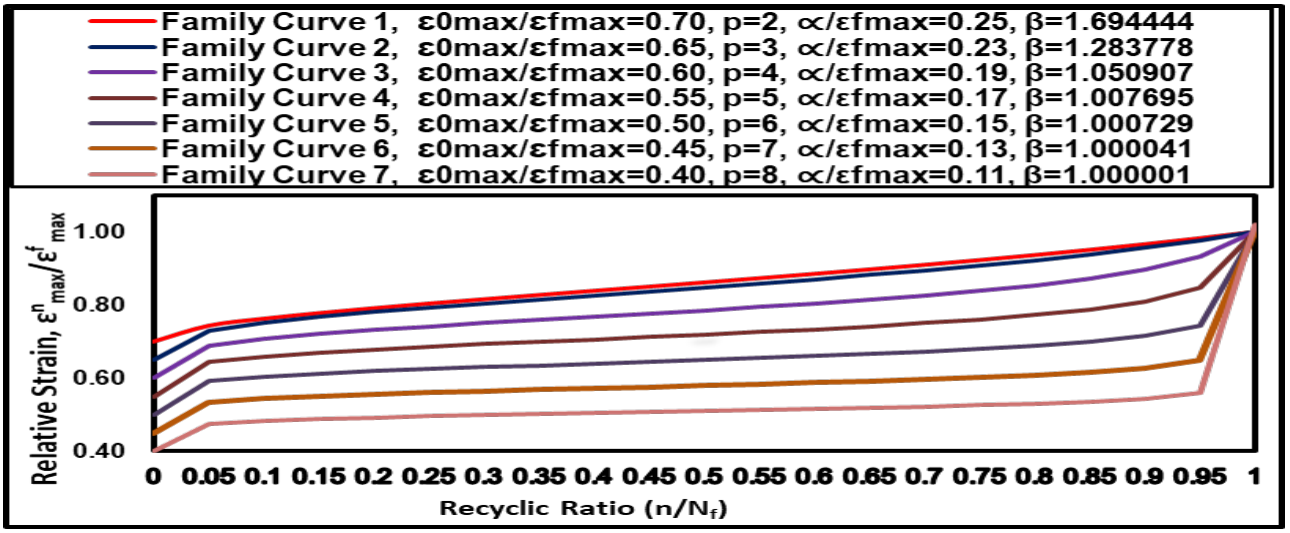

Figure 14: Concrete Fatigue Strain Evolution, Family Strain Curve (i) $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.70, p=2.00, $\propto/\varepsilon^f_{max}$=0.25, β=1.694444 (ii) $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.65, p=3.00, $\propto/\varepsilon^f_{max}$=0.23, β=1.283778 (iii) $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.60, p=4.00, $\propto/\varepsilon^f_{max}$=0.19, β=1.050907 (iv) $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.55, p=5.00, $\propto/\varepsilon^f_{max}$=0.17, β=1.007695 (v) $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.50, p=6.00, $\propto/\varepsilon^f_{max}$=0.15, β=1.000729 (vi) $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.45, p=7.00, $\propto/\varepsilon^f_{max}$=0.13, β=1.000041 (vii) $\varepsilon^0_{max}/\varepsilon^f_{max}$ =0.40, p=8.00, $\propto/\varepsilon^f_{max}$=0.11, β=1.000001

Figure (4) and (5) shows the increase in damage with increasing loading cycles. The experimental work of Figure [11] is also shown for comparison. Theoretical model which is also shown well captures the similar nature of increment of damage with respect to fatigue cyclic loading as observed in the experiment [11]. For numerical simulation, the following constant were used, A = 0.10 and β = 0.15 and 0.00 in two cases, Parameter A is estimated by comparing predicted results and experimental results over a range of applied strains.

Figures (6) and (7) depict the theoretical cyclical stress-strain behavior of concrete material in tension. In Figure (6), no permanent deformations are found on the condition of fatigue unloading of concrete material but progressive damage is accumulated in each fatigue loading cycle due to the reduction of elastic modulus. In fact, it is an ideal case for elastic-perfectly damaging behavior in damage mechanics which can be obtained by letting $\beta = 0$with assuming that crack surfaces i.e. microcracks, macrocracks, etc. shall close perfectly upon unloading. As the concrete material is heterogeneous, therefore it falls on permanent deformations after fatigue loading and unloading. Figure 7 shows the versatile behavior of the model where the stiffness degradation and permanent deformation are illustrated simultaneously.

VI. Conclusion

a) Concrete Fatigue Strain-based evolution Model by utilizing continuum thermodynamics Approach

Fatigue Strain Based Approach for Damage Evolution Model of Concrete materials during low frequency is presented by utilizing the framework of continuum thermodynamics of Continuum Mechanics by taking two material fatigue damage parameter i.e. A=fatigue damage Parameter regarding energy microcracks of the material particle and another is β=kinematic damage Parameter (phenomena of material crack surface close perfectly after unloading). For the production of concrete, except cement, all materials are locally available i.e. sand, aggregate, and water. So, it is very much popular in the list of construction material is construction engineering. Concrete is a heterogeneous matrix related to the composition i.e. cement, sand, aggregate and water among them cement is the weakest part compared to the remaining ingredients. So, fatigue damage in concrete in the fatigue process is obviously due to the development of internal micro-cracks, microvoids, macrocracks, a cycle-dependent damage surface is obtained in the formulation of the model. Fatigue damage evolution law regarding functions of damage response were obtained and used in the developing the constitutive relation to demonstrating the capacity for validation of the model for further diagnosis of concrete material, relate to stiffness degradation including inelastic deformations, under tension-tension, tension-compression fatigue loading by finding out the cumulative fatigue damage parameter i.e. K. The curve regarding fatigue response at A =0.10 and β =0.15 and 0.00 is calculated firstly by the modeling and after that this generated model curve is compared to the Curve obtained from the experimental data of Peiyin Lu. Et al (2004) which shows similar tread of generation of fatigue curve. This shows the good relationship between results obtained from modeling and experiments also. Lower value in the experimental curve is due to 0.85 times maximum stress level whereas, modeling takes 100% value.

b) Ordinary Concrete Fatigue Strain Evolution Model

The model curve regarding maximum fatigue strain and fatigue residual strain under different strain and stress levels using the model formulas (21) to (22) are described in Figures. Coefficients of different damage parameters regarding the evolutionary model are shown in Table. The data in the figure for the Strain Family Curve are the average of each group. From Figures (12), (13), (14) and Table of Fatigue Strain evolutionary Model, fatigue strain evolution equations (21) and (22) can be a good fit to the experimental data. Correlation coefficients are above 0.98. The evolution in the sense of fatigue damage parameter regarding maximum fatigue strain and fatigue residual strain has been plotted which clearly shows the similar three-phase variation at the different intermediate stage close to the linear change in their behavior. When the cycle ratio is exceeded by 0.90 then the curve converged rapidly. The level-S shaped curve of strain evolution is from the lower left corner to the upper right corner in the plotting of graph. This is due to experimenting measured of initial maximum strain and lacking measurement of initial residual strain, the strain evolution curve regarding maximum strain starts from the initial value, but the strain evolution curve of fatigue residual strain starts from zero. This is due to the defect in the material structure and de-orientation of molecules of the concrete. Based on the Model formation on the basis of $(0, \varepsilon f_{max} - \varepsilon^{0}_{max})$. α fall in these the prescribed ranges while fitting of the curve is done surrounding its prescribed boundary conditions.

Authors' contributions

All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

Not applicable.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Not applicable.

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Table 1: Data analysis for fatigue curve regarding stiffness, cumulative Damage Parameter verses Number of Cycle of Concrete

Assuming , Fatigue Damage Factor related to Surface Energy Microcracks i.e. A= 0.10 and Fatigue Kinematic Damage Factor (Crack Surface closed perfectly after unloading) i.e. β=0.00									
N (Number of Cycle)	**Fatigue Damage Parameter (A)**	**Stiffness factor (β)**	**E0**	**εu**	**Exp(sqrt((1-2xβ)xN^Axεux εu)/εu)**	**(E0-k)/E0**	**(Eo-k)**	**1-((E0-k)/E0)**	**Fatigue Damage Parameter, K**
1	0.1	0.00	2.34E+10	1E-04	2.718281828	0.367879	8608378923	0.632120559	14791621077
2	0.1	0.00	2.34E+10	1E-04	2.815852123	0.355132	8310095480	0.644867715	15089904520
3	0.1	0.00	2.34E+10	1E-04	2.876192321	0.347682	8135756372	0.652318104	15264243628
4	0.1	0.00	2.34E+10	1E-04	2.920554404	0.342401	8012177404	0.657599256	15387822596
5	0.1	0.00	2.34E+10	1E-04	2.955885852	0.338308	7916408539	0.661691943	15483591461
6	0.1	0.00	2.34E+10	1E-04	2.985369569	0.334967	7838225541	0.665033097	15561774459
7	0.1	0.00	2.34E+10	1E-04	3.010740403	0.332144	7772174570	0.667855788	15627825430
8	0.1	0.00	2.34E+10	1E-04	3.0330523	0.329701	7715000497	0.670299124	15684999503
9	0.1	0.00	2.34E+10	1E-04	3.052995299	0.327547	7664604006	0.67245282	15735395994
10	0.1	0.00	2.34E+10	1E-04	3.071046719	0.325622	7619551945	0.674378122	15780448055
20	0.1	0.00	2.34E+10	1E-04	3.194997641	0.312989	7323949068	0.687010724	16076050932
30	0.1	0.00	2.34E+10	1E-04	3.271916231	0.305631	7151772341	0.694368703	16248227659
40	0.1	0.00	2.34E+10	1E-04	3.328592706	0.300427	7029997981	0.699572736	16370002019
50	0.1	0.00	2.34E+10	1E-04	3.373807035	0.296401	6935784933	0.703598934	16464215067
60	0.1	0.00	2.34E+10	1E-04	3.411588452	0.293119	6858975029	0.706881409	16541024971
70	0.1	0.00	2.34E+10	1E-04	3.444135968	0.290349	6794156857	0.709651416	16605843143
80	0.1	0.00	2.34E+10	1E-04	3.472786939	0.287953	6738104126	0.712046832	16661895874
90	0.1	0.00	2.34E+10	1E-04	3.498417763	0.285844	6688738048	0.714156494	16711261952
100	0.1	0.00	2.34E+10	1E-04	3.521635146	0.283959	6644640638	0.716040998	16755359362
200	0.1	0.00	2.34E+10	1E-04	3.681503839	0.271628	6356098221	0.728371871	17043901779
300	0.1	0.00	2.34E+10	1E-04	3.781094589	0.264474	6188684110	0.73552632	17211315890
400	0.1	0.00	2.34E+10	1E-04	3.854660161	0.259426	6070574065	0.740573758	17329425935
500	0.1	0.00	2.34E+10	1E-04	3.913457797	0.255528	5979366896	0.7444715	17420633104
600	0.1	0.00	2.34E+10	1E-04	3.962663371	0.252356	5905119312	0.747644474	17494880688
700	0.1	0.00	2.34E+10	1E-04	4.005105817	0.249681	5842542263	0.750318707	17557457737
800	0.1	0.00	2.34E+10	1E-04	4.042507649	0.247371	5788486265	0.752628792	17611513735
900	0.1	0.00	2.34E+10	1E-04	4.075998823	0.245339	5740924131	0.754661362	17659075869
1000	0.1	0.00	2.34E+10	1E-04	4.106362272	0.243525	5698474331	0.756475456	17701525669

Table 2: Data Analysis for Fatigue Curve regarding Maximum Stress Verses Number of Cycle and Damage Factor Parameter Verses Number of Cycle

Assuming , Fatigue Damage Factor related to Surface Energy Microcracks i.e. A= 0.10 and Fatigue Kinematic Damage Factor (Crack Surface closed perfectly after unloading) i.e. β=0.00 at different Number of Cycle							
N	**$K**	**K**	**E**	**$stress**	**maximim stress**	**resudial strain**	**Log(N)**
1	1282173402	0	23400000000	2114008.7	2114008.703	0.000204421	0
2	670041551	1282173402	22117826598	2091299.33	2091299.328	0.000202493	0.30103
3	458458692	1952214953	21447785047	2061344.27	2061344.267	0.000201791	0.477121
4	350269622	2410673645	20989326355	2034632.17	2034632.172	0.000201418	0.60206
5	284280732	2760943267	20639056733	2011362.18	2011362.182	0.000201185	0.69897
6	239711345	3045223999	20354776001	1990921.92	1990921.916	0.000201023	0.778151
7	207530075	3284935345	20115064655	1972746.93	1972746.93	0.000200905	0.845098
8	183169905	3492465419	19907534581	1956400.11	1956400.112	0.000200813	0.90309
9	164069326	3675635324	19724364676	1941550.91	1941550.908	0.00020074	0.954243
10	148678707	3839704650	19560295350	1927947.54	1927947.54	0.000200681	1
11	136004711	3988383357	19411616643	1915395.34	1915395.344	0.000200631	1.041393
12	125380779	4124388068	19275611932	1903741.33	1903741.327	0.000200589	1.079181
13	116342712	4249768847	19150231153	1892863.35	1892863.347	0.000200553	1.113943
14	108557141	4366111560	19033888440	1882662.48	1882662.476	0.000200522	1.146128
15	101778373	4474668701	18925331299	1873057.53	1873057.529	0.000200494	1.176091
16	95821285.7	4576447074	18823552926	1863981.1	1863981.099	0.000200469	1.20412
17	90543702.5	4672268359	18727731641	1855376.62	1855376.622	0.000200448	1.230449
18	85834594.3	4762812062	18637187938	1847196.18	1847196.182	0.000200428	1.255273
19	81605972.8	4848646656	18551353344	1839398.83	1839398.832	0.00020041	1.278754
20	77787194.3	4930252629	18469747371	1831949.31	1831949.314	0.000200394	1.30103
21	74320876.4	5008039823	18391960177	1824817.05	1824817.047	0.000200379	1.322219
22	71159917.7	5082360700	18317639300	1817975.34	1817975.34	0.000200366	1.342423
23	68265288.9	5153520617	18246479383	1811400.75	1811400.754	0.000200353	1.361728
24	65604369.8	5221785906	18178214094	1805072.6	1805072.596	0.000200342	1.380211
25	63149682.3	5287390276	18112609724	1798972.51	1798972.506	0.000200331	1.39794
26	60877913.1	5350539958	18049460042	1793084.12	1793084.116	0.000200321	1.414973
27	58769151.4	5411417871	17988582129	1787392.77	1787392.775	0.000200312	1.431364
28	56806288.3	5470187023	17929812977	1781885.31	1781885.312	0.000200303	1.447158
29	54974539.3	5526993311	17873006689	1776549.85	1776549.846	0.000200295	1.462398
30	53261061.7	5581967850	17818032150	1771375.62	1771375.621	0.000200287	1.477121
31	51654644.9	5635228912	17764771088	1766352.87	1766352.869	0.00020028	1.491362
32	50145458.4	5686883557	17713116443	1761472.69	1761472.69	0.000200273	1.50515
33	48724845.3	5737029016	17662970984	1756726.95	1756726.954	0.000200267	1.518514
34	47385151.8	5785753861	17614246139	1752108.21	1752108.211	0.000200261	1.531479
35	46119585.2	5833139013	17566860987	1747609.62	1747609.624	0.000200255	1.544068
36	44922096.4	5879258598	17520741402	1743224.89	1743224.894	0.000200249	1.556303
37	43787280.1	5924180694	17475819306	1738948.21	1738948.212	0.000200244	1.568202

Table 3: Maximum Stress Observed by Peiyin Lu.Et al 2004 through Experiment

Smax	No. of Cycle	Factor	Max. Stress
0.85	1479000	2.2	158.4893192
0.84	1461600	2.3	199.5262315
0.75	1305000	4.1	12589.25412
0.74	1287600	4.4	25118.86432
0.69	1200600	5.05	112201.8454
0.685	1191900	5.2	158489.3192
0.68	1183200	5.75	562341.3252
0.65	1131000	6.2	1584893.192
0.63	1096200	6.3	1995262.315

Table 4: Damage Predicted by Peiyin Lu.Et al 2004 through Experirment

Damage	Cyclic Ratio
0.16	0
0.17	0.02
0.172	0.04
0.18	0.05
0.19	0.08
0.195	0.1
0.2	0.12
0.21	0.145
0.22	0.198
0.23	0.24
0.24	0.255
0.25	0.28
0.26	0.32
0.28	0.37
0.3	0.395
0.31	0.43
0.36	0.52
0.4	0.585
0.48	0.68
0.55	0.72
0.7	0.88
0.88	1

Fatigue Evoluation Model

Table 5: Influence of fatigue strain Parameter "P" on Fatigue strain Curve by Putting the value of (i) P=2.00, β=1.25 (ii) P=3.00, β=.1.125 (iii) P=4.00. β=1.0625 (iv) P=5.00, β=1.0315 (v) P=6.00, β=1.015625 (vi) P=7.00, β=1.003906 and $\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$=0.60 and $\alpha/\varepsilon^{f}_{max}$=0.20

n/N_f	$\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$	$\alpha/\varepsilon^{f}_{max}$	β	p	β/(β-n/Nf)	$(\beta/(\beta-n/N_f)-1)^{(1/p)}$	$\varepsilon^{n}_{max}/\varepsilon^{f}_{max}$	ε^{n}_{max}
0	0.6	0.20	1.25	2	1	0	0.6	0.60
0.05	0.6	0.20	1.25	2	1.041666667	0.204124145	0.640824829	0.64
0.1	0.6	0.20	1.25	2	1.086956522	0.294883912	0.658976782	0.66
0.15	0.6	0.20	1.25	2	1.136363636	0.369274473	0.673854895	0.67
0.2	0.6	0.20	1.25	2	1.19047619	0.43643578	0.687287156	0.69
0.25	0.6	0.20	1.25	2	1.25	0.5	0.7	0.70
0.3	0.6	0.20	1.25	2	1.315789474	0.561951487	0.712390297	0.71
0.35	0.6	0.20	1.25	2	1.388888889	0.623609564	0.724721913	0.72
0.4	0.6	0.20	1.25	2	1.470588235	0.685994341	0.737198868	0.74
0.45	0.6	0.20	1.25	2	1.5625	0.75	0.75	0.75
0.5	0.6	0.20	1.25	2	1.666666667	0.816496581	0.763299316	0.76
0.55	0.6	0.20	1.25	2	1.785714286	0.88640526	0.777281052	0.78
0.6	0.6	0.20	1.25	2	1.923076923	0.960768923	0.792153785	0.79
0.65	0.6	0.20	1.25	2	2.083333333	1.040833	0.8081666	0.81
0.7	0.6	0.20	1.25	2	2.272727273	1.12815215	0.82563043	0.83
0.75	0.6	0.20	1.25	2	2.5	1.224744871	0.844948974	0.84
0.8	0.6	0.20	1.25	2	2.777777778	1.333333333	0.866666667	0.87
0.85	0.6	0.20	1.25	2	3.125	1.457737974	0.891547595	0.89
0.9	0.6	0.20	1.25	2	3.571428571	1.603567451	0.92071349	0.92
0.95	0.6	0.20	1.25	2	4.166666667	1.779513042	0.955902608	0.96
1	0.6	0.20	1.25	2	5	2	1	1.00

Fatigue Evoluation Model

Table 6: Infiuence of Fatigue Strin Parameter "α" on fatigue Strain Curve , putting the value of (i) $\alpha/\varepsilon^{f}_{max}$=0.10, β= 1.05 and $\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$=0.60 and P=2

n/N_f	$\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$	$\alpha/\varepsilon^{f}_{max}$	β	p	$\beta/(\beta-n/Nf)$	$(\beta/(\beta-n/N_f)-1)^{(1/p)}$	$\varepsilon^{n}_{max}/\varepsilon^{f}_{max}$	$\varepsilon^{n}_{max}/\varepsilon_{max}$
0	0.6	0.10	1.0625	2	1	0	0.6	0.60
0.05	0.6	0.10	1.0625	2	1.049382716	0.222222222	0.622222222	0.62
0.1	0.6	0.10	1.0625	2	1.103896104	0.322329186	0.632232919	0.63
0.15	0.6	0.10	1.0625	2	1.164383562	0.405442427	0.640544243	0.64
0.2	0.6	0.10	1.0625	2	1.231884058	0.481543412	0.648154341	0.65
0.25	0.6	0.10	1.0625	2	1.307692308	0.554700196	0.65547002	0.66
0.3	0.6	0.10	1.0625	2	1.393442623	0.627250048	0.662725005	0.66
0.35	0.6	0.10	1.0625	2	1.49122807	0.700876644	0.670087664	0.67
0.4	0.6	0.10	1.0625	2	1.603773585	0.77702869	0.677702869	0.68
0.45	0.6	0.10	1.0625	2	1.734693878	0.857142857	0.685714286	0.69
0.5	0.6	0.10	1.0625	2	1.888888889	0.942809042	0.694280904	0.69
0.55	0.6	0.10	1.0625	2	2.073170732	1.035939541	0.703593954	0.70
0.6	0.6	0.10	1.0625	2	2.297297297	1.138989595	0.713898959	0.71
0.65	0.6	0.10	1.0625	2	2.575757576	1.255291829	0.725529183	0.73
0.7	0.6	0.10	1.0625	2	2.931034483	1.389616668	0.738961667	0.74
0.75	0.6	0.10	1.0625	2	3.4	1.549193338	0.754919334	0.75
0.8	0.6	0.10	1.0625	2	4.047619048	1.745743122	0.774574312	0.77
0.85	0.6	0.10	1.0625	2	5	2	0.8	0.80
0.9	0.6	0.10	1.0625	2	6.538461538	2.353393622	0.835339362	0.84
0.95	0.6	0.10	1.0625	2	9.444444444	2.905932629	0.890593263	0.89
1	0.6	0.10	1.0625	2	17	4	1	1.00

Calculation of fatigue Evolution Factor i.e. β

Table 7: Calculation of Fatigue Strain Parameter "β" on Fatigue Strain Curve, putting the value of (i) $\alpha/\varepsilon f$ max=0.10 to1.05, β=1.05 and $\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$=0.60 and P=2

p	$\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$	$\propto/\varepsilon^{f}_{max}$	$(1-\varepsilon^{0}_{max}/\varepsilon^{f}_{max})$	$(1-\varepsilon^{0}max/\varepsilon fmax)/(\propto/\varepsilon^{f}_{max})^{-p}$	$\beta=((1-\varepsilon 0max/\varepsilon fmax)/(\propto/\varepsilon^{f}_{max}))+1$
2	0.6	0.10	0.4	0.0625	1.0625
2	0.6	0.15	0.4	0.140625	1.140625
2	0.6	0.20	0.4	0.25	1.25
2	0.6	0.25	0.4	0.390625	1.390625
2	0.6	0.30	0.4	0.5625	1.5625
2	0.6	0.35	0.4	0.765625	1.765625
2	0.6	0.40	0.4	1	2
2	0.6	0.45	0.4	1.265625	2.265625
2	0.6	0.50	0.4	1.5625	2.5625
2	0.6	0.55	0.4	1.890625	2.890625
2	0.6	0.60	0.4	2.25	3.25
2	0.6	0.65	0.4	2.640625	3.640625
2	0.6	0.70	0.4	3.0625	4.0625
2	0.6	0.75	0.4	3.515625	4.515625
2	0.6	0.80	0.4	4	5
2	0.6	0.85	0.4	4.515625	5.515625
2	0.6	0.90	0.4	5.0625	6.0625
2	0.6	0.95	0.4	5.640625	6.640625
2	0.6	1.00	0.4	6.25	7.25
2	0.6	1.05	0.4	6.890625	7.890625

Fatigue Evoluation Model

Table 8: S-shaped curve family of fatigue strain, $\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$=0.70,P=2.00, $\alpha/\varepsilon^{f}_{max}$ =0.25, β=1.694444

n/N_f	$\varepsilon^{0}_{max}/\varepsilon^{f}_{max}$	$\propto/\varepsilon^{f}_{max}$	β	p	β/(β-n/Nf)	$(\beta/(\beta-n/N_f)-1)^{(1/p)}$	$\varepsilon^{n}_{max}/\varepsilon^{f}_{max}$	$\varepsilon^{n}_{max}/\varepsilon^{f}_{max}$
0	0.7	0.25	1.69444	2	1	0	0.7	0.70
0.05	0.7	0.25	1.69444	2	1.0304055	0.174371694	0.743592923	0.74
0.1	0.7	0.25	1.69444	2	1.0627179	0.25043551	0.762608878	0.76
0.15	0.7	0.25	1.69444	2	1.0971226	0.311644961	0.77791124	0.78
0.2	0.7	0.25	1.69444	2	1.1338294	0.365827	0.79145675	0.79
0.25	0.7	0.25	1.69444	2	1.1730775	0.416025787	0.804006447	0.80
0.3	0.7	0.25	1.69444	2	1.2151401	0.463832004	0.815958001	0.82
0.35	0.7	0.25	1.69444	2	1.2603314	0.510226851	0.827556713	0.83
0.4	0.7	0.25	1.69444	2	1.3090139	0.55589022	0.838972555	0.84
0.45	0.7	0.25	1.69444	2	1.3616084	0.601338868	0.850334717	0.85
0.5	0.7	0.25	1.69444	2	1.4186062	0.646997843	0.861749461	0.86
0.55	0.7	0.25	1.69444	2	1.4805844	0.693241942	0.873310486	0.87
0.6	0.7	0.25	1.69444	2	1.5482256	0.740422566	0.885105642	0.89
0.65	0.7	0.25	1.69444	2	1.6223431	0.788887238	0.897221809	0.90
0.7	0.7	0.25	1.69444	2	1.7039138	0.838995686	0.909748921	0.91
0.75	0.7	0.25	1.69444	2	1.7941214	0.891134885	0.922783721	0.92
0.8	0.7	0.25	1.69444	2	1.8944144	0.945734837	0.936433709	0.94
0.85	0.7	0.25	1.69444	2	2.0065842	1.003286721	0.95082168	0.95
0.9	0.7	0.25	1.69444	2	2.1328735	1.06436529	0.966091323	0.97
0.95	0.7	0.25	1.69444	2	2.276127	1.129657922	0.982414481	0.98
1	0.7	0.25	1.69444	2	2.4400092	1.20000384	1.00000096	1.00

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We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSE member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

AUXILIARY MEMBERSHIPS

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

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Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

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2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

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Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
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- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

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Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. 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.

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

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

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

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

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. 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 for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

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

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon 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 for 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 of 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 criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to 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 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 avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

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

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite 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 approaches 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. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a 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 limit the initial two items to no more than one line each.

Reason for writing the article—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 for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity 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 of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets 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 for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory 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 soundly written procedures segment allows a capable scientist to replicate 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 to give the least amount of information that would permit another capable scientist to replicate 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 section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show 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:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the 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—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and 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 as 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. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give 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 manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit 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 section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an 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 implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully 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 the prospect, and let it drop at that. Make a decision as to whether each premise is supported or 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 an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of 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 other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	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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