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ORIGINAL CONTRIBUTION

Retrofitting of Short Columns by Utilizing Different Galvanized Steel Meshes to Improve Strength Properties

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***Abstract*— Retrofitting is the process of adding modern systems to older buildings to make them sustainable. Retrofitting of RC short columns may be defined as an attempt to restore the original strength and stiffness of damaged as well as deteriorated RC short columns. The main purpose of this research project is that many older structures today require strengthening their existing civil engineering infrastructure. The reasons are deterioration by aging or corrosion caused by environmental factors, load increase because of a change of function in the structure, or poor design which does not meet the present more stringent design requirements such as in earthquake areas. In this research, Welded wire mesh was used for Retrofitting to study its confining effect. UN retrofitted & Retrofitted Columns are crushed in UTM. The result observed was positive with a high percentage of increase in strength properties particularly in the case of utilizing square iron mesh which is 14.87% and 34.44% in compressive and tensile strength respectively.**

***Index Terms*— Concrete, Iron mesh, Retrofitting, Columns**

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I. INTRODUCTION

Structural engineering has extensively investigated reinforced concrete structure behavior and failure modes [1]. The majority of construction efforts now focus on renovating older structures. A building will typically completely collapse if its most crucial structural component, such a column fails [2]. To strengthen RC columns, a variety of alternate methods can be used.

Re-strengthening damaged columns is one of the most cutting edge techniques for allowing them to carry structural loads [3].

Depending on their application, the replacement of structurally weak concrete, the fiber warps technology, and external jacketing is typically employed to re-strengthen RC columns. External jacketing for RC columns is often made of RCC jacketing, steel jacketing, ferro cement jacketing, etc. [4]. Aging and overburdened infrastructure are increasingly becoming a threat to public safety, economy, and quality of life. Steel structures comprise a large portion of the existing infrastructure worldwide [5]. Steel constructions in general and steel bridges in particular, a number of elements have the potential to seriously damage them. RCC structural members are retrofitted in order to restore the strength of degraded structural concrete components and stop future concrete distress [6]. Common issues associated with a lack of strength include structural cracks, damage to structural parts, excessive loads, mistakes made during design or construction, modifications to the structural system, seismic damage, corrosion brought on by honeycomb infiltration, etc. [7]. Section enlargement, external plate bonding, external post-tensioning, grouting, fiber-reinforced polymer composites, and jacketing are just a few of the methods utilized to retrofit structural elements. A good retrofitting technique is specified and used in accordance with the extent of the damage and the necessary capacity to be recovered [8].

A form of retrofitting method used to strengthen structures and building components is called jacketing. There are numerous forms of jacketing, including those made of steel, reinforced concrete, fiber-reinforced polymer composite, high-tension jackets made of materials like carbon fiber, glass fiber, etc., and jackets made of ferro cement [9]. Before achieving their intended design life, structures made of this material frequently sustain damage as a result of overloading, fire, different environmental impacts (such as corrosion), overloading, overloading, natural catastrophes (such as an earthquake, tsunami, cyclone, flood, etc.), fire, change in building usage, etc. [10]. For exterior jacketing of RC columns, materials like RCC jacketing, steel jacketing, ferro cement jacketing, etc. This jacketing is relatively simple to apply to the RC column, requiring no special skills [11]. Numerous technical qualities, including tensile and flexural strengths, toughness, fracture, crack control, fatigue resistance, and impact resistance, are in-

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creased in RCC jacketing or other materials due to the homogeneous distribution of reinforcement [12]. In developing nations, RCC jacketing is the best type of jacketing due to its low material cost and unique fire and corrosion prevention properties.

Using the FRP strengthening approach in square RC columns, some research has been done to lessen the stress concentration at the corners. One of them is jacketing with rounded column corners, which reduces stress concentration at the corners of the square RC column and provides varying degrees of confinement. In this study, every feasible method of ferro cement jacketing is used experimentally to obtain a square ferro cement jacketing technique that is effective for reinforcing square short RC columns [13, 14]. The majority of previous concrete buildings that did not meet the special requirements of the current seismic design codes have shown significant damage or have completely collapsed, according to the experience of earthquakes that have occurred over the past few decades (including those in Agadir, Morocco, 1960; Chile; and Managua, Nicaragua, in 1972) [15]. Such reinforced concrete structures' collapse, which is predominantly due to column failures, is attributed to inadequate transverse reinforcement details (widely spaced hoops with open hooks) and inadequate longitudinal reinforcement anchorage [16].

According to reports, external Ferro cement jacketing improves a column's rigidity while also boosting its strength. The external jacket of circular RC columns subjected to axial compression uniformly limits the concrete core, and the behavior of such a uniformly confined concrete core with various confining materials has been thoroughly researched. In the most recent years, researchers have also researched lateral confinement for square columns using various confinement strategies [17]. Researchers put square columns through tests with both circular and square Ferro cement jacketing while simultaneously applying compressive and seismic loads. To reinforce rectangular RC columns, Tsai and Lin suggested using steel jackets that were octagonal and slightly modified octagonal in shape. For the purpose of strengthening square RC columns, jackets in octagonal and modified octagonal shapes are both appropriate [18]. An experimental and numerical investigation about the steel-concrete composite column was done by structural engineers. The results demonstrated that the load-carrying capability and ductility were improved [19]. To examine the impact of these jackets on the overall behavior, they conducted a series of experiments on short composite concrete-steel columns in 2005. It was tested to see how well steel jackets will enclose columns made of Normal Strength Concrete (NSC) and High Strength Concrete (HSC). With a significant shift in the deformation capacity and an increase in the ultimate stress-strain, more cracks were seen than in unconfined columns [20]. Investigated are the behaviors of circular and square columns made of standard concrete and recycled aggregate concrete that has had steel jackets added. Both varieties failed to withstand the overall buckling, according to the test results. But another issue with durability is the rusting of steel plates. [21, 22, 23].

Given the benefits it offers over NC, including as its better tensile qualities and updated durability against extreme environmental effects, Engineered Cementitious Composites (ECCs), a type of High Performance-Concrete (HPC), is now frequently used [24, 25, 26, 27]. After the initial crack, ECC could show tensile strain hardening due to its 400 times greater strain capacity than NC. The composite action between reinforcing steel and concrete may also be enhanced by the increased ductility offered by ECC. Additionally, ECC has narrower fissures, which could prevent corrosion and increase the ductility of reinforcing steel. [27, 28, 29, 30, 31, 32, 33, 34, 11] According to research on square RC columns with steel jacketing, the stress block parameters and, cm, and can all be used to reliably measure the ultimate bending strength of retrofitted RC columns. Aakawa's equation and the design formula for calculating the limit rotation angle can be used to determine the shear strength of the retrofitted RC columns. Ru, specified and described, reasonably predicted the experimental deformation capacity of the retrofitted RC column [35]. The axial load-carrying and deformation capacities of FRP jacketed concrete members over unjacketed concrete members have been improved, and the factors influencing the axial stress-strain behavior of FRP confined concretes are identified, according to research on the behavior of circular and square RC columns jacketed with FRP [36].

The following are the objectives of this investigation

- To show the High Load Carrying Capacity of Column.
- To Increase the lifetime of Existing Structure.
- To study the behavior of Iron mesh in Short Columns.
- To Use Welded Wire Mesh as confinement reinforcement for concrete.
- Columns to improve the earthquake resistance of structures.

II. MATERIAL AND METHODS

The investigation makes use of the following materials. Casting and testing short columns made up the experimental work. The size of each column was the same. 6" dia. and 18" tall circular cross sections made up the columns' cross-sections. This section covers the material characteristics, the molding, and the test setup created for carrying out the current inquiry. Twelve specimens were produced in this study using various configurations of restricting mesh, whereas six examples were cast using only plain concrete. Locally accessible galvanized iron welded wire mesh (GW mesh) (ASTMA185/A185M) was employed for confinement in order to study the impact of the placement of WWM in RC columns. There were two major groupings formed from the specimens. For comparison, group-2 specimens were cast with no mesh at all while GW mesh was wrapped around exterior cores in group-1. The test subjects were placed under an axial stress.

A. Cement

In a broader meaning, cement is an adhesive substance of all kinds. However, in a more specific sense, it is the binding substance utilized in building and civil engineering construction. This type of cement is made of powders that have been finely powdered and are combined with water to form a hard mass. Lucky Cement Factory, a well-known and high-quality brand in Pakistan, provided the cement for this study. The compressive strengths of this cement are given in the following ratios.

TABLE I
CEMENT USED IN THE SAMPLES CASTING

S. No.	Cement Grade	Mix Ratio (Cement: Sand: Aggregate)	Compressive Strength
1	M7.5	1: 4: 8	1087 Psi
2	M10	1 : 3: 6	1450 Psi
3	M15	1: 2: 4	2175 Psi
4	M20	1: 1.5 : 3	2900 Psi

B. Sand

Sand is a combination of very minute fragments of various rocks or minerals. The sand sample utilized in this study was collected near Peshawar, Pakistan, close to Ring Road.

C. Aggregate (Finer and Coarse)

Fine aggregates are essentially any natural sand particles that are extracted from the earth through mining. Fine aggregates are any broken stone fragments that are 14" or smaller, such as natural sand. This might apply to crushed gravel and crushed stone as well. While coarse aggregate describes components used to make concrete that are granular and uneven, such sand, gravel, or crushed stone. The majority of the time, coarse can be obtained by blasting quarries or by manually crushing them in crushers. The crusher factory located close to Kohat Road in Peshawar, Pakistan, is where these samples were collected.

D. Iron Mesh

Welded wire mesh, welded wire fabric, or simply "weld mesh" is a prefabricated linked grid that has been electric fusion welded. It is made up of a number of parallel longitudinal wires that have been precisely spaced and joined to cross wires at the necessary intervals. The mesh is produced with precise dimensional control by machines. Galvanized iron welded wire mesh (GW mesh) is the type of iron mesh employed in this experiment.

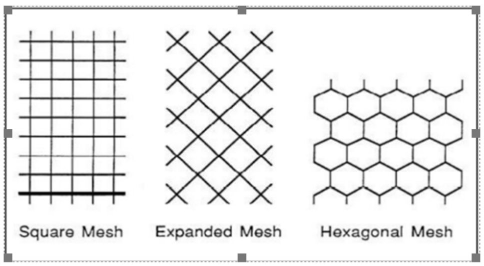

Fig. 1. Iron meshes

Fig. 2. Galvanized iron welded wire mesh (GW mesh)

III. RESULTS AND DISCUSSION

Following are the results of different experiments done for this research.

A. Compressive Strength

1) Without iron mesh (Trail 1):

We test three samples of the cylinders without iron mesh one by one in the initial trials. All test specimens were kept in a dry location for a few hours following the completion of the curing process to achieve a surface dry condition. After that, tests were run on a hydraulic compression-testing device. As you apply axial load, note the maximum load at failure by applying a constant 14 N/mm2 (140 kg/cm2) per minute load rate until failure occurs. Up until failure, the load was applied to the top of the specimen.

TABLE II
COMPRESSIVE STRENGTH OF WITHOUT IRON MESH SAMPLE

S. No.	Samples	Compressive Strength (Psi)
1	C1	1175.25
2	C2	1173.35
3	C3	1172

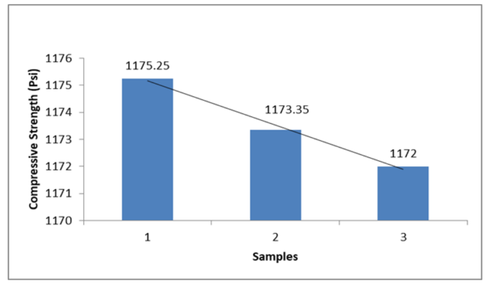

Fig. 3. Compressive Strength Graph of without Iron Mesh Sample

2) With square iron mesh (Trail 2):

In this trial, three samples of cylinders are tested individually using a square iron mesh. All test specimens were stored in a dry location for a few hours following the completion of the curing process to achieve a surface dry condition. After that, tests were run on a hydraulic compression-testing device. As you apply axial load, note the maximum load at failure by applying a constant 14 N/mm2 (140 kg/cm2) per minute load rate until failure occurs. Up to failure, the load was applied to the top of the specimen.

TABLE III
COMPRESSIVE STRENGTH OF SQUARE IRON MESH SAMPLE

S. No.	Samples	Compressive Strength (Psi)
1	A1	1508.39
2	A2	1444.57
3	A3	1210.06

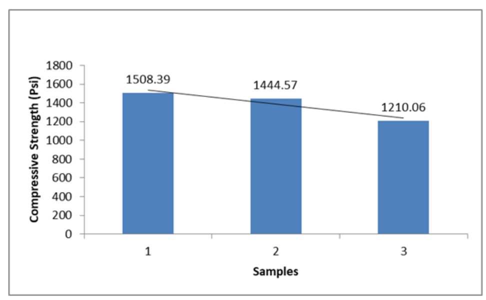

Fig. 4. Compressive Strength Graph of Square Iron Mesh Sample

3) With diagonal iron mesh (Trail 3):

We put three samples of cylinders through this trial, testing each one individually with a square iron mesh. All specimens were stored in a dry environment for a few hours after the test specimens had finished drying in order to achieve a surface dry condition. A hydraulic compression-testing machine was then used for the experiments. When failure occurs, note the highest load at failure and continue applying force axially at a constant rate of 14 N/mm2 (140 kg/cm2) per minute. Up until the specimen's failure, the weight was applied at its top.

TABLE IV
COMPRESSIVE STRENGTH OF DIAGONAL IRON MESH SAMPLE

S. No.	Samples	Compressive Strength (Psi)
1	B1	1190.76
2	B2	1050
3	B3	1348

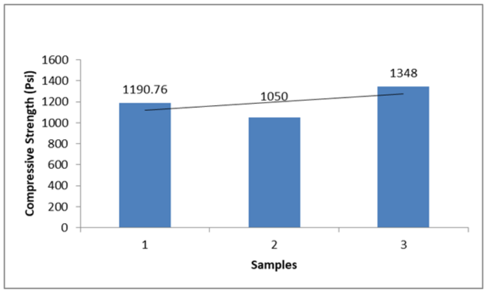

Fig. 5. Compressive Strength Graph of Diagonal Iron Mesh Sample

B. Tensile Strength

1) Without iron mesh (Trail 1)

We evaluate three samples of the cylinders without iron mesh one by one in the initial trials. All test specimens were stored in a dry location for a few hours following the completion of the curing process to achieve a surface dry condition. After that, tests were run on a hydraulic compression-testing device.

TABLE V
TENSILE STRENGTH OF WITHOUT IRON MESH SAMPLE

S. No.	Samples	Tensile Strength (Psi)
1	C1	552
2	C2	589
3	C3	572

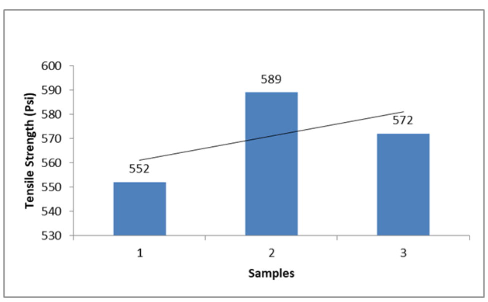

Fig. 6. Tensile Strength Graph of without Iron Mesh Sample

2) With square iron mesh (Trail 2):

In this trial, three samples of cylinders are tested individually using a square iron mesh. All test specimens were stored in a dry location for a few hours following the completion of the curing process to achieve a surface dry condition. After that, tests were run on a hydraulic compression-testing device.

TABLE VI
TENSILE STRENGTH OF SQUARE IRON MESH SAMPLE

S. No.	Samples	Tensile Strength (Psi)
1	C1	871
2	C2	889
3	C3	856

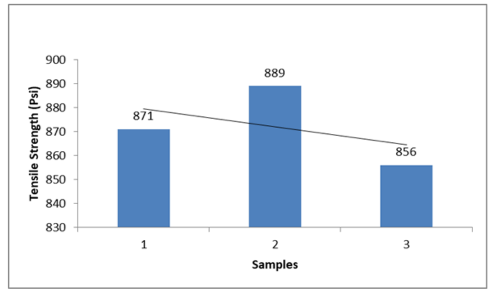

Fig. 7. Tensile Strength Graph of Square Iron Mesh Sample

3) With diagonal iron mesh (Trail 3):

In this trial, three samples of cylinders are tested individually using a square iron mesh. All test specimens were stored in a dry location for a few hours following the completion of the curing process to achieve a surface dry condition. After that, tests were run on a hydraulic compression-testing device.

TABLE VII
TENSILE STRENGTH OF DIAGONAL IRON MESH SAMPLE

S. No.	Samples	Tensile Strength (Psi)
1	C1	725
2	C2	744
3	C3	769

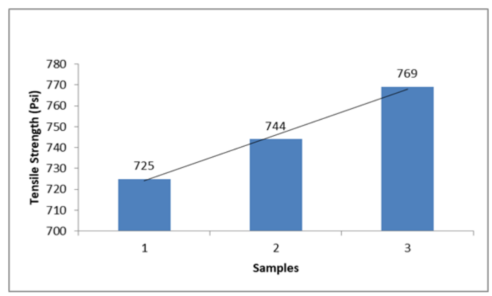

Fig. 8. Tensile Strength Graph of Diagonal Iron Mesh Sample

IV. CONCLUSION

Two separate control specimens (without retrofitting) and nine specimens with retrofitting were constructed, retrofitted, and tested in this investigation using eleven half-scale concrete column specimens. These test samples were divided into three series, the first of which lacked an iron mesh. Square iron mesh was used in the second series, and a diagonal iron mesh was used in the third series. In this test, steel jacketing was used as a retrofit approach. According to the test results, the main conclusions are as follows:

- In the retrofitted columns, it was found that the average compressive strength was rising at a higher rate, particularly in the case of the square iron mesh, which is up to 14.87%. Furthermore, the percentage rise in the case of diagonal wire mesh is only approximately 2 to 3 percent, which is quite little.
- Using and not using wire mesh significantly increased the peak load and the deformation capacity. Therefore, the retrofit targets (increasing shear strength and deformation capacity) and (enhancing deformation capacity) were accomplished and confirmed from the test results.

- Additionally, it was found that the retrofitted columns' average tensile strength was rising, particularly in the case of the square iron mesh, which has an increase of about 34.44%. Additionally, the percentage increase in the case of diagonal wire mesh is approximately 23.45%, which is not a negligibly small increase.

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