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FLEXURAL STRENGTHENING OF HYBRID BEAM WITH SRG COMPOSITES

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ABSTRACT

In this paper the flexural performance of hybrid beam strengthened with the U-shaped SRG (Steel Reinforced Grout) composites were analytically analyzed using Finite Element software (ANSYS). The use of analytical techniques and Finite Element Software ANSYS provides a rigorous and accurate approach to investigating the structural behavior of these systems. In order to strengthen existing structures, Steel Reinforced Grout (SRG) are being used more and more. The main aim of this studies were (i) To find out the length optimization of steel reinforced grout. (ii) Splitting the optimized concrete model into four layers with compressive strengths of M30 and M20 then determine the load bearing capacity by analyzing the concrete height ratios of 1:3, 1:1, and 3:1. It can help optimize the design of such structures by demonstrating the impact of concrete height on the functionality of hybrid beams.

Keywords – ANSYS, Flexural Performance, Hybrid Beam, Optimal Length, Steel Reinforced Grout,

1. INTRODUCTION

When structures and buildings were built in the first decades of the 20th century, RC quickly became a vital and necessary construction material, the need for rehabilitation was more obvious. Even though working understanding of RC was still developing and building rules did not address durability difficulties, a sizable number of structures, some of them with historical value, were created. In terms of mechanical properties and durability requirements, low-grade concrete structures constructed at the period could never have complied with modern building standards. Innovative, practical, and affordable solutions have been the focus of numerous research teams. Midway through the 1990s, Fiber Reinforced Concrete (FRP) was first used for the strengthened retrofitting of RC structures. Since then, FRP has become a well-liked material in a field that is frequently hesitant to adopt new methods or materials. The well-known benefits of FRP composites over conventional reinforcing procedures have been documented in several studies, including their simplicity in application, resistance to corrosion, negligible specific weight, high tensile strength, and flexibility. Although many materials are utilised for this purpose, including steel wire (Steel Reinforced Polymer, or SRP), carbon fibre fabrics. Despite its benefits, FRP external retrofitting is still not a frequently used solution since many designers still favour traditional methods. The substance utilized as the composite matrix, epoxy resins, has compatibility issues with particular substrates, which causes premature debonding and poorer strengthening. The glass transition phase, which is not particularly high in some materials, is where they act poorly. Epoxy resins' high economic cost when compared to traditional processes, which mostly use steel and concrete, is another significant disadvantage. Furthermore, because using these techniques has permanent impacts, the employment of FRPs is prohibited in the case of heritage interventions.

A composite system known as Steel Reinforced Grout (SRG) has been created in recent years. The material has been employed in RC components during the past few years, and a number of European research groups and institutes are actively looking into potential applications, ranging from rehabilitation (as an externally bonded strengthening system) to the creation of precast components. Steel wire has drawn the most attention among all the materials that could be employed as the composite core. The twisted wire cables used to construct this material into a cloth. Because to its characteristics, the steel wire-based composite is commonly referred to as steel reinforced grout (SRG). In this technique, galvanized ultra-high-strength steel wires are twisted into cords, joined into unidirectional textiles, and then embedded in a matrix made of inorganic cement. To prevent rusting and salt damage, steel textiles are typically composed of stainless steel, coated with brass or zinc, or both. Even though they are few in number, some theoretical and experimental investigations have been done to study the structural performances of both reinforced concrete beams enhanced in flexure or in shear as well as the mechanical properties of the SRG systems. The obtained results demonstrated the efficiency of SRGs as strengthening systems and demonstrated that slippage phenomena at the interface between concrete and SRG systems and/or steel fabric and mortar influenced the performances of members enhanced with SRGs. According to the findings of a recent experimental analysis, using SRG to strengthen reinforced concrete beams in shear and flexure represents an efficient option from both a strength and deformability point of view.

In this paper the hybrid beam is created by combining two different materials. In this scenario, compressive strength of M30 and M20 were combined to generate a hybrid beam then determine whether the load carrying capacity has increased.

These are the study's primary goals.

- To determine the SRG's optimal length.
- To compare the flexural strengthening of hybrid beams using different concrete amounts

2. MODELLING

2.1 DESCRIPTION OF NUMERICAL MODELS

Using the ANSYS Finite Element Code software, a numerical approach can be used to investigate the behaviour of SRG flexural strengthened reinforced concrete beams. The model beams have a length of 3000 mm and a cross section of 200 x 300 mm. SRG U-wraps were offered at various distances, including 400, 800, 1200, 1600mm, etc.. Moreover, there were two 18mm-diameter bars on the compression side and three 18mm-diameter bars on the tension side of the internal longitudinal steel reinforcement of the beams. Simply said, non-symmetric three point bending is used to support all beams. For all of the beams, the span-to-height cross section ratio, or a/h, was 3.0. Steel stirrups with an 8mm diameter and a 200mm spacing between them were installed along a 3000mm length of the SRG flexural strengthening system to test its performance. Each side of the beams has a 20mm thick concrete coating.

2.2 MATERIAL PROPERTIES AND GEOMETRIC DIMENSION

The material characteristics of steel are listed in Table1, the properties of SRG are listed in Table 2, the properties of concrete are listed in Table 3, and the geometrical dimensions of the beam are shown in Figure 1.

Table1- Material properties of steel

Young’s Modulus	2x10^5	MPa
Poison’s ratio	0.3	-
Yield strength	250	MPa
Ultimate strength	565	MPa

Considering a Bilinear isotropic hardening Material model for incorporating the plasticity of steel

Table2- Linear Material properties of SRG

Young’s Modulus	144789.9	MPa
Poison’s ratio	0.3	-
Yield strength	247	MPa

U-wrap thickness is 5mm and the interaction between the beam and nail, and between the nail and the external reinforcement, was considered as a perfect bond”

Table3- Properties of concrete

Compressive strength	20	MPa
Tensile Strength	2.8	MPa
Poisson’s ratio	0.2	-

Considering as the multilinear isotropic hardening property of concrete.

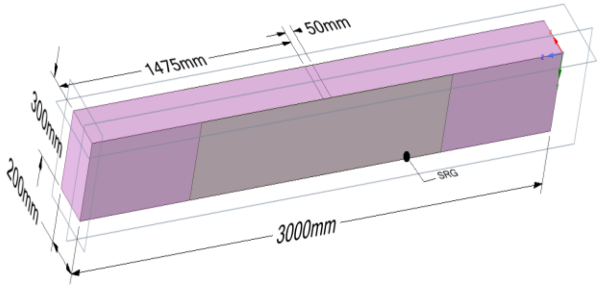

Fig 1: Geometric dimension of the beam

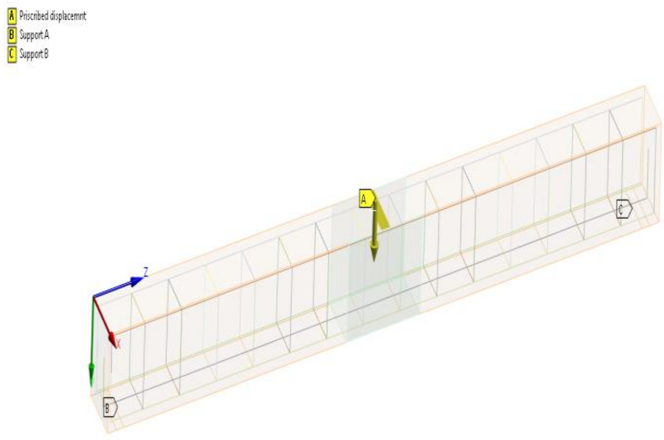

Fig 3: loading of the beam

Table5- Boundary condition and Loading

	Tx	Ty	Tz	Rx	Ry	Rz
Remote displacement 1	0	0	0	Free	0	0
Remote displacement 2	0	0	Free	Free	0	0
Displacement	Ty= 12.5mm					

2.3 MESHING

The displacement changes significantly when element size is changed, and since the displacements of the elements with sizes of 20mm and 30mm are 13.24mm and 13.24mm, respectively, it appears that the mesh has converged. As a result, pick the larger element size (30mm) from the mesh convergence study to speed up computation.

Table4- Mesh Details

Parts	Mesh type	Element order
Concrete (3D)	HEX20	Linear
SRG (2D)	Quad 4	Linear
Reinforcement(1D)	Link 180	Linear

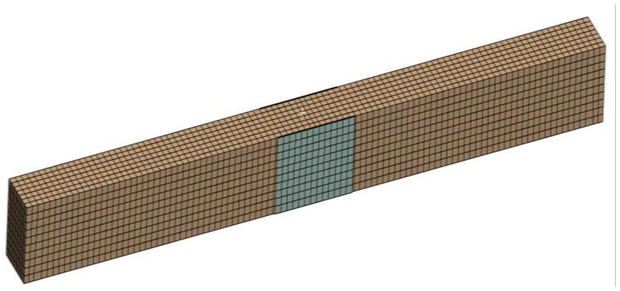

Fig 2: Meshing of the beam

2.4 LOADING AND BOUNDARY CONDITIONS

Support B is used as a pin support, and Support C is used as a hinge support. A predetermined displacement of 12.5mm is applied (Y direction).

3. ANALYSIS

SRG of lengths 400, 800, 1200, 1600, and 2000mm were installed in the middle of a 3000mm beam. The maximum loading carrying capacity of the beam is determined by comparing the load displacement graphs and determining the percentage variations in each ultimate load with regard to one another. By dividing the optimized concrete model into four layers with compressive strength of M20 and M30. Analyze the data again for concrete height ratios of 1:3, 1:1, 3:1. By highlighting the effect of concrete height on the functionality of hybrid beams, it can assist in improving the design of such structures. Determine the hybrid beam's maximum load-bearing capacity

4. RESULTS AND DISCUSSIONS

4.1 length optimization of SRG

4.1.1 SRG of length 400mm

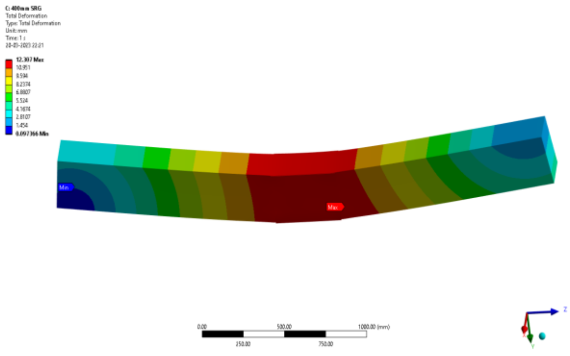

Fig 4: Deformation of the beam with 400mm SRG

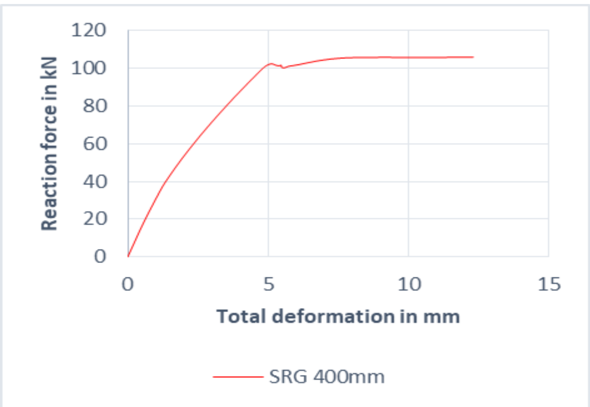

Fig 5: Ultimate load of the beam is 106.03kN

4.1.2 SRG of length 800mm

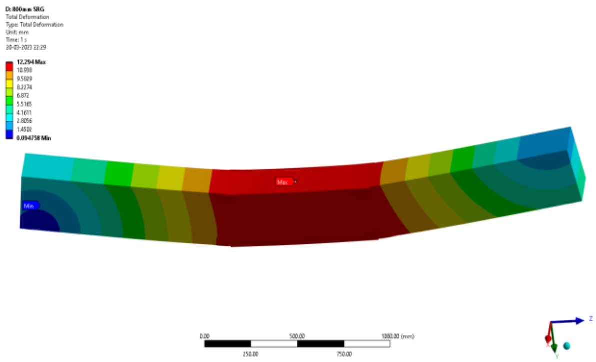

Fig 6: Deformation of the beam with 800mm SRG

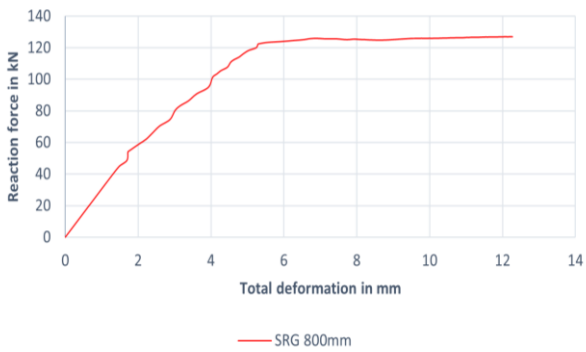

Fig 7: Ultimate load of the beam is 127.04kN

4.1.3 SRG of length 1200mm

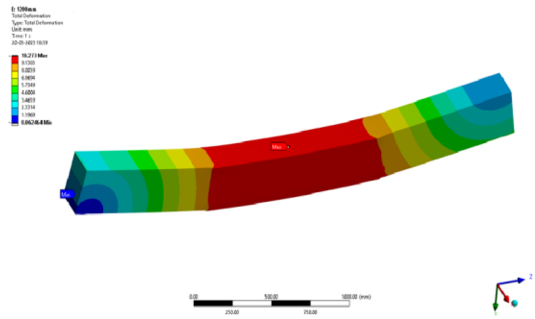

Fig 8: Deformation of the beam with 1200mm SRG

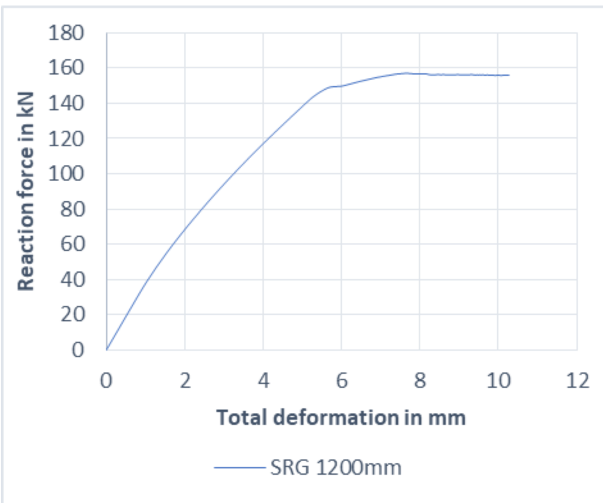

Fig 9: Ultimate load of the beam is 156.04kN

4.1.4 SRG of length 1600mm

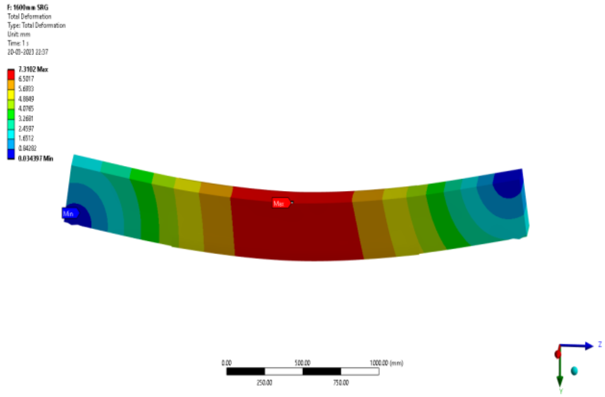

Fig 10: Deformation of the beam with 1600mm SRG

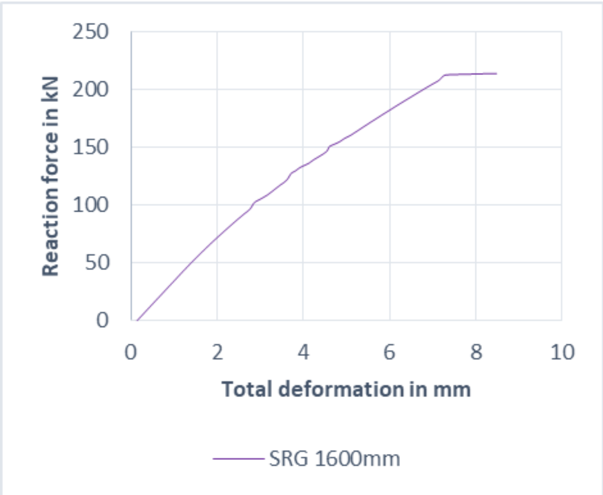

Fig 11: Ultimate load of the beam is 215.69kN

4.1.5 SRG of length 2000mm

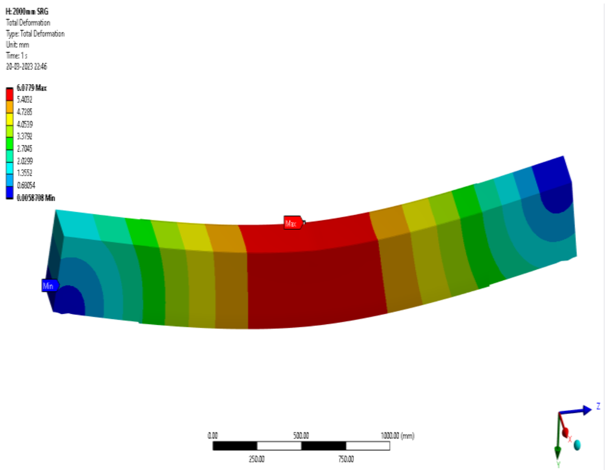

Fig 12: Deformation of the beam with 2000mm SRG

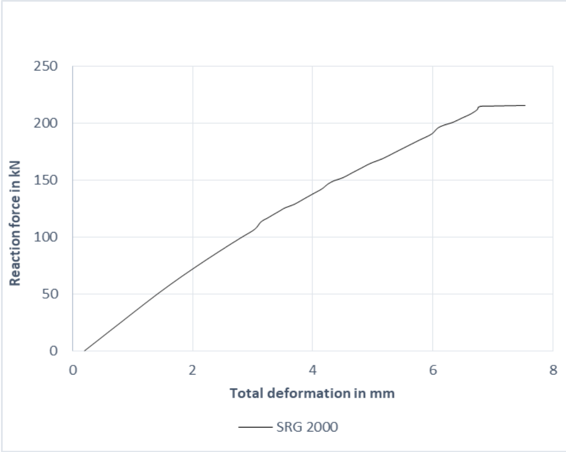

Fig 13: Ultimate load of the beam is 216.0kN

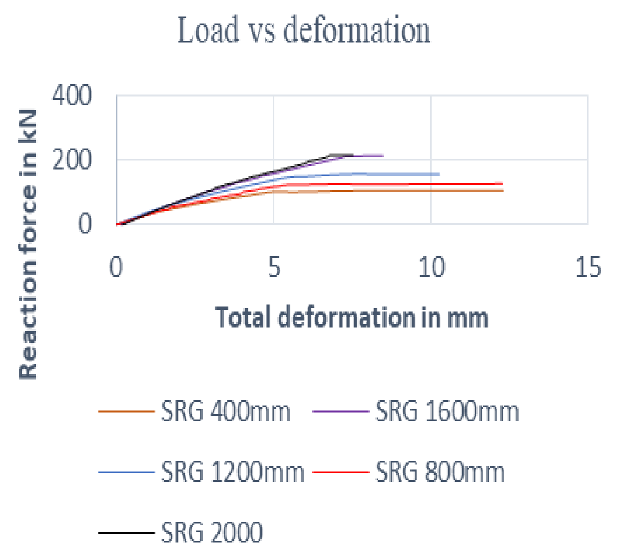

Fig 14: Comparison of the Ultimate load of the beam with SRG 400, 800, 1200, 1600, 2000mm.

Table6- Ultimate load of beam (KN)

SL No	SRG length (mm)	Ultimate load of beam (KN)
1	400	106.03
2	800	127.04
3	1200	156.04
4	1600	215.69
5	2000	216.0

4.2 Flexural strengthening of hybrid beams using different concrete amounts

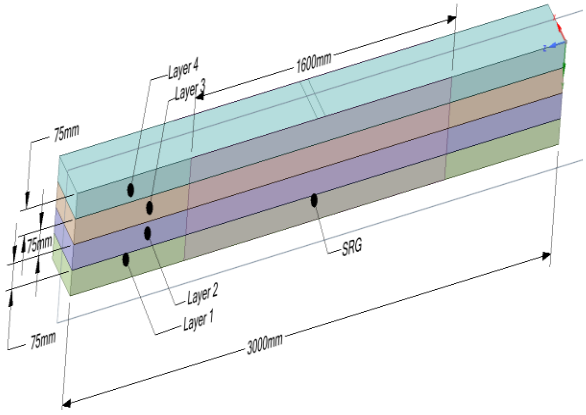

Fig 15: Hybrid beam of M30 and M15

4.2.1 1600mm SRG M30 and M20 concrete ratio 1:3

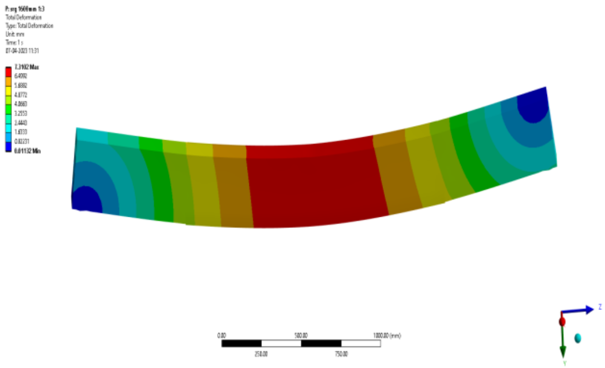

Fig 16: Deformation of the 1600mm hybrid beam having ratio of 1:3

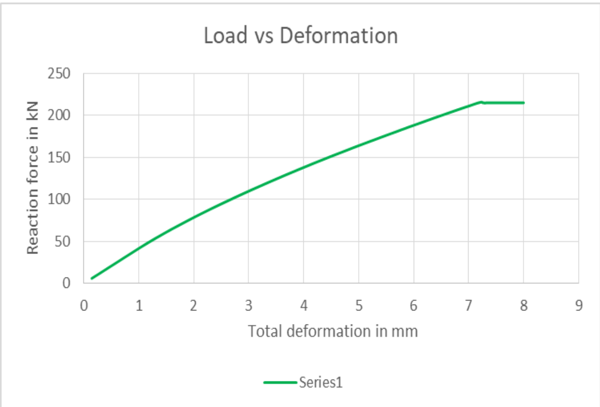

Fig 17: Ultimate load of the beam is 215.0kN

4.2.2 1600mm SRG M30 and M20 concrete ratio 1:1

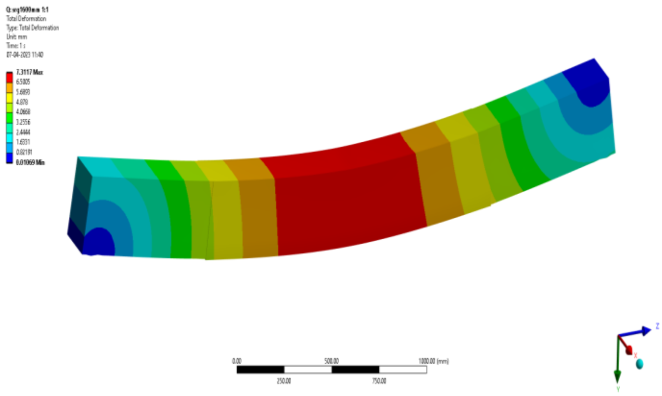

Fig 18: Deformation of the 1600mm hybrid beam having ratio of 1:1

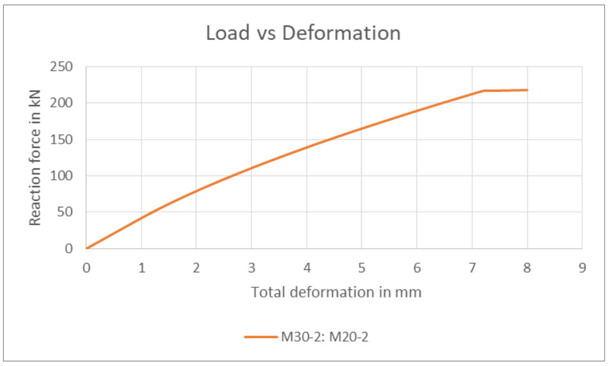

Fig 19: Ultimate load of the beam is 217.76kN

4.2.3 1600mm SRG M30 and M20 concrete ratio 3:1

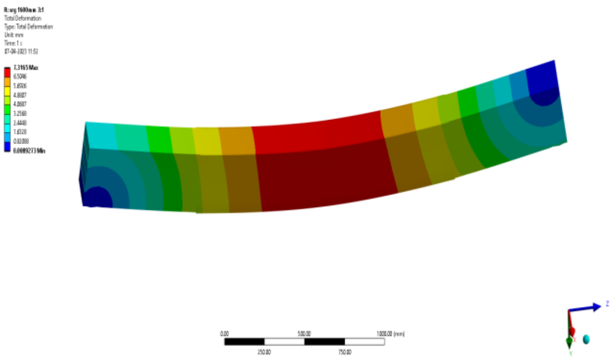

Fig 20: Ultimate load of the beam is 216.0kN

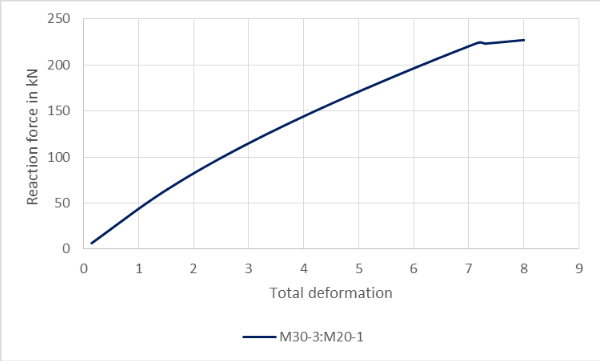

Fig 21: Ultimate load of the beam is 216.0kN

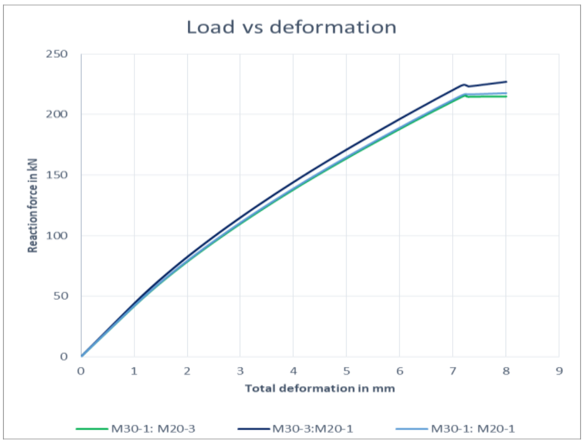

Fig 22: Comparison of the Ultimate load of the beam with SRG 1600mm having ratio of 1:3, 1:1, 3:1

Table7- Ultimate load of Hybrid beam (KN)

Sl No	SRG Length (mm)	Ultimate load of Hybrid beam (kN)
1	M30-1:M20-3	215.0
2	M30-2:M20-2	217.76
3	M30-3: M20-1	227.14

5. CONCLUSION

Deformation of the beam decreases as SRG length increases. SRG length optimization has been done, and it has been discovered that SRG is not required after a length of 1600mm. By drawing this conclusion, I've come to the conclusion that increasing SRG beyond 1600mm won't make a significant difference in the amount of stress that the beam can support. That could be a time and money waste. Thus, 1600mm might be thought of as the SRG's ideal length.

Comparing the ultimate load carrying capacities of hybrid beams with ratios of 1:3, 1:1, and 3:1, we can see that the maximum ultimate load of 3:1 is higher than the maximum ultimate load of the other two ratios, leading us to infer that the hybrid beam with a 227kN is taken into consideration.

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