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NUMERICAL INVESTIGATION OF A NON-PRISMATIC GIRDER WITH SINUSOIDAL CORRUGATED STEEL WEB AND STEEL GRID

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Abstract - Bridges are considered to be one of the vital parts of infrastructural systems. Concrete box is one of the most commonly used structural form as girders. The corrugated webs provided in the concrete box girder prevent the structure from failure due to loss of stability. The existing studies on bridge girders with steel corrugated webs are focused on single trapezoidal arrangement. But the large forces are generated on girders result in buckling of these.

In this thesis Numerical investigation of a non-prismatic simply supported overhanging girder with sinusoidal corrugated steel web and steel grid is done. Web is a flexural member in bridge girder which is required to carry heavy loads on relatively long spans. Conventional flat plate steel girders are used most commonly as webs. To overcome its limitations of poor web stability and low buckling strength, corrugated steel webs are used. To enhance the flexural strength and buckling capacity of corrugated steel web, different models of single sinusoidal, double sinusoidal, single sinusoidal with stiffeners, trusses connecting corrugated webs, Ultra-Light weight Cement Concrete (ULCC) infill are used. Another model of steel grid is also used as web. Non-linear buckling analysis of non-prismatic girder with sinusoidal corrugated steel web and steel grid are carried out using ANSYS 2021 R1 software. Parametric investigations in terms of flexural actions such as shear in steel and concrete are also conducted. The results shows that non-prismatic girder with double sinusoidal corrugated web infilled with ULCC have more strength and better load carrying capacity as compared to other type of girders. Effect on sinusoidal and trapezoidal corrugated steel webs shows that sinusoidal corrugation shows better performance than trapezoidal corrugation.

***Key words*:** Non-prismatic girder, Sinusoidal corrugated web, Non-linear analysis, Finite Element Analysis

1.INTRODUCTION

The plate girder is a built-up beam with plates in the web and flange. These were designed to bear immense loads over long spans. The common types of plate girders include riveted plate girders, bolted plate girders and welded plate girders. Welded plate girders had supplanted riveted and bolted plate girders by the 1950s due to their superior quality, aesthetic appearances, and reduced construction cost. A plate girder fails mainly by web buckling, flange buckling, or fatigue failure. The main components of a plate girder include flange, web plate, stiffeners (vertical, horizontal, inclined), flange and web splices and end connections. Due to the advantage of large loads for longer spans, these are often used in ships and platforms, cranes, elevators, and gantry beams.

A corrugated web plate girders are plate girders with corrugated web instead of flat web. Due to the corrugated web, beams have more shear stability than ordinary flat web beams, so the stiffeners and thicker web plates required can be reduced. These structures have a unique design in which the corrugated steel in the web is optimised to achieve maximum stability and load carrying capacity. The corrugations in the web prevent the beam from failure due to loss of stability before the web yields. The corrugated web in girder has more material than the girder of the same size with a flat web. Compared to hot rolled beams, corrugated web girders offer a substantial weight reduction due to the thin web. The corrugated web beams are a novel constructional system that has arisen in many structural designs. The corrugation geometries of rectangular, trapezoidal, triangular, and sinusoidal are possible.

In recent years, the corrugation of the trapezoidal and sinusoidal has become a more and more popular choice of corrugations that are shown in fig.1.1 and fig .1.2. The Corrugated Steel Web (CSW) in bridges results in lower seismic stresses and lighter substructures, leading to a cost-effective and easy construction. The performance of corrugated web girders was proven to be improved from that of ordinary beams, with CSWs having enhanced stability against shear buckling, less weight, and longer service life.

Bridge girders with corrugated webs have a number of advantages such as more out of plane stiffness, higher buckling resistance and shear capacity, excellent strength and web stability than that of conventional flat web girders. Some examples of bridges provided with corrugated steel web girders are the Maupre Bridge constructed in France and the Hondani Bridge constructed in Japan. According to previous researches, large forces generated on the girders result in buckling of single corrugated steel webs. For improving strength and stability, double corrugated webs can be provided. That is, to investigate non-prismatic girder with two corrugated steel webs which are placed parallel and connecting them by using diagonal trusses or Ultra Light Cement Concrete (ULCC) is infilled in between double sinusoidal corrugated steel webs. And also to compare the sinusoidal and trapezoidal corrugated girders. In addition to this, the ultimate load carrying capacity of non-prismatic girders with steels grid are analysed.

2. OBJECTIVES

- To investigate load bearing capacity and buckling strength of Non-prismatic girder with sinusoidal corrugated steel web, trapezoidal corrugated steel web and steel grid using ANSYS software
- To compare the effect of sinusoidal corrugated steel web and trapezoidal corrugated steel web.
- To compare the effect of single and double sinusoidal corrugated steel webs.

3. METHODOLOGY

The whole project is divided into sequential steps. The following chart represents the methodology of the work.

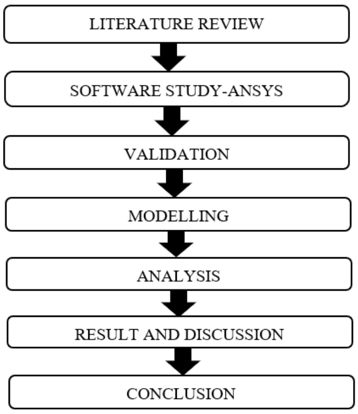

Fig. 3.1 Flow chart diagram for methodology

4. NUMERICAL MODELLING

The Non-prismatic girder with sinusoidal corrugated steel web section was modelled using ANSYS Workbench software. All materials were considered isotropic. Numerical modelling of eight types of non-prismatic girders are chosen for analysis such as Non-prismatic girder with single sinusoidal corrugated steel web, Non-prismatic girder with single trapezoidal corrugated steel web, Non-prismatic girder with single sinusoidal corrugated steel web and stiffener, Non-prismatic girder with single trapezoidal corrugated steel web and stiffeners, Non-prismatic girder with double sinusoidal corrugated steel web, Non-prismatic girder with double sinusoidal corrugated steel web and trusses, Non-prismatic girder with double sinusoidal corrugated steel web with ULCC infill, Non-prismatic girder with steel grid. Here 5mm thickness corrugated steel webs are used. Properties of materials used for modelling is shown in table 4.1.

Table-4.1: Material properties of steel and concrete

Materials	Young's modulus	Poisson's ratio	Density	Grade
Concrete	34.5 GPa	0.2	2500kg/ m^3	M20
Steel	209 GPa	0.3	7800kg/ m^3	Fe250

There are 8 models in total including non-prismatic girder with single trapezoidal corrugated webs. Each of these have different strengthening scheme as described below:

Table-4.2: Model name and description

Model name	Model description
NSSC	Non-prismatic girder with single sinusoidal corrugated steel web
NSTC	Non-prismatic girder with single trapezoidal corrugated steel web
NSSC-S	Non-prismatic girder with single sinusoidal corrugated steel web and stiffeners
NSTS-S	Non-prismatic girder with single trapezoidal corrugated steel web and stiffeners
NDSC	Non-prismatic girder with double sinusoidal corrugated steel web
NDSC-TR	Non-prismatic girder with double sinusoidal corrugated steel web and trusses
NDSC-ULCC	Non-prismatic girder with double sinusoidal corrugated steel web with concrete infill
NG	Non-prismatic girder with steel grid

Fig. 4.3 shows modelling of a non-prismatic girder with single sinusoidal corrugated steel web

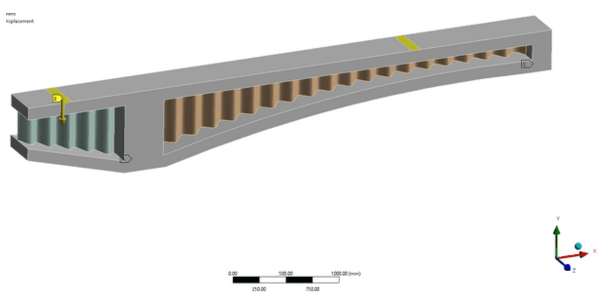

Fig 4.3. Modelling of NSSC

Fig. 4.4 shows modelling of a non-prismatic girder with single trapezoidal corrugated steel web

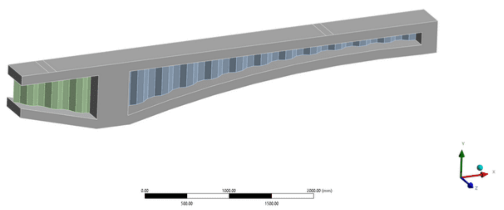

Fig 4.4. Modelling of NSTC

Fig. 4.5 shows modelling of a non-prismatic girder with single sinusoidal corrugated steel web and stiffeners provided longitudinally at each interval of corrugations. Here stiffeners are provided with 5mm thickness.

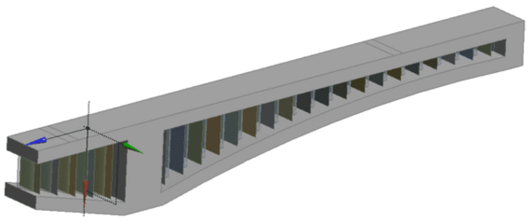

Fig 4.5. Modelling of NSSC-S

Fig. 4.6 shows modelling of a non-prismatic girder with single trapezoidal corrugated steel web and stiffeners provided longitudinally at each interval of corrugations. Here stiffeners are provided with 5mm thickness.

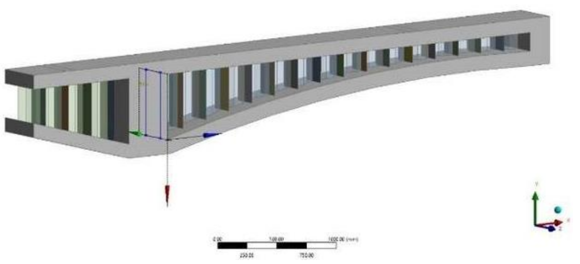

Fig 4.6. Modelling of NSTC-S

Fig 4.7 show modelling of a non-prismatic girder with double sinusoidal corrugated steel web and the distance between two corrugations are 200mm.

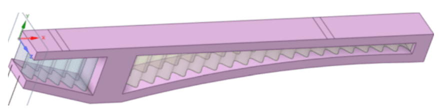

Fig 4.7. Modelling of NDSC

Fig. 4.8 shows modelling of a non-prismatic girder with double sinusoidal corrugated steel web and trusses. Trusses with 20mm diameter are provided diagonally in between sinusoidal corrugated steel webs.

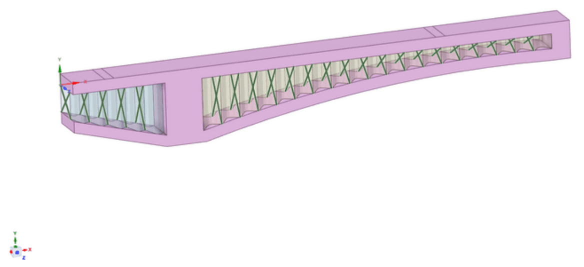

Fig 4.8. Modelling of NDSC-TR

Fig 4.9 shows modelling of a non-prismatic girder with double sinusoidal corrugated steel web with ULCC infill. Here density of 1250 kg/m^3 ULCC is filled in between sinusoidal corrugated steel webs.

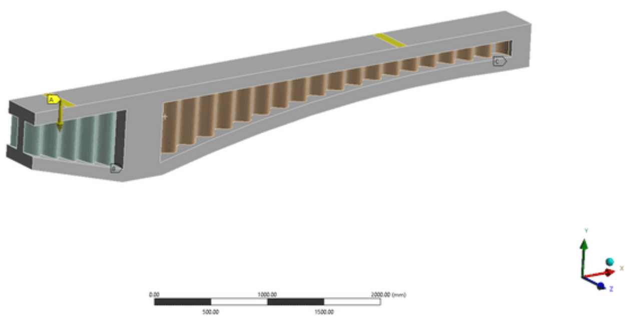

Fig 4.9. Modelling of NDSC-ULCC

Fig. 4.10 shows modelling of a non-prismatic girder with steel grid. Here 10mm diameter steel bars are arranged in grid type and provided in between top and bottom flanges of non-prismatic beam.

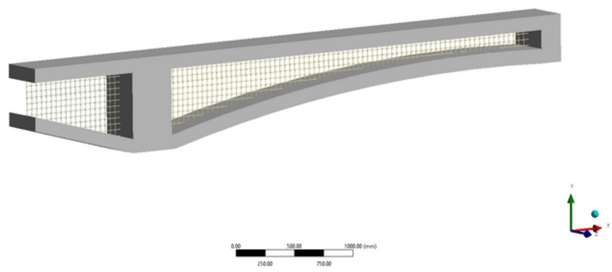

Fig. 4.10 Modelling of NG

5. NUMERICAL ANALYSIS

Analysis of non-prismatic beam is done using ANSYS 2021 R1. ANSYS is the most advance, comprehensive finite element analysis and design software available for structural engineering. It is a unique and powerful tool having a wide range of civil engineering applications.

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5.2. ANALYSIS

For the analysis of the model, different deformation loads are applied on the model one by one. This helps to identify the effect of each loads on the model. The below figures shows the load bearing capacity and buckling load in different parts of model due to different loading conditions. Here 50mm mesh size is suitable for the analysis. Displacement constrain is selected for applying the boundary conditions. Displacement load of 10mm is gradually applied on the top of each models.

5.2.1. Non-prismatic girder with single sinusoidal corrugated steel web (NSSC)

Fig. 5.1 shows meshing of non-prismatic beam with single sinusoidal corrugated steel web. Concrete and steel section is provided with mesh size of 50mm.

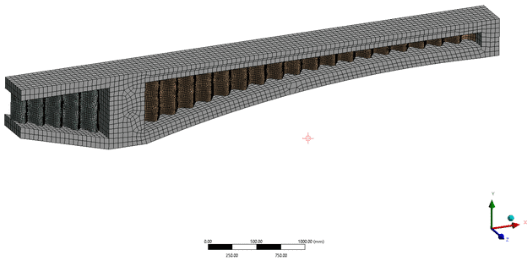

Fig. 5.1 Meshing of NSSC

Fig. 5.2 shows boundary conditions and loading of non-prismatic beam with single sinusoidal corrugated steel web. At the end of simply supported region roller support is provided and the end where overhanging is started, hinged support is provided.

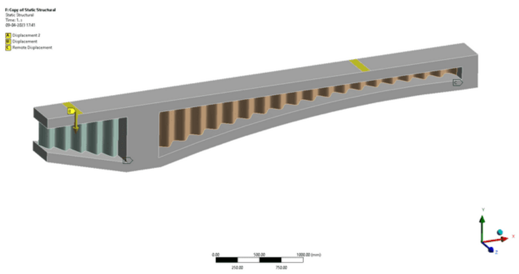

Fig.5.2 Boundary conditions and loading of NSSC

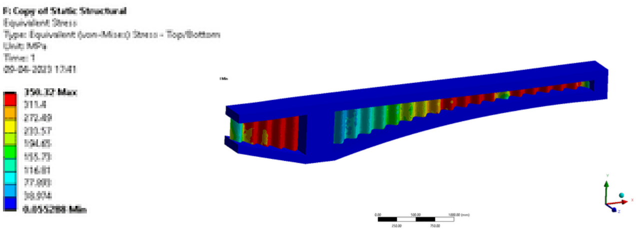

Fig. 5.3 Equivalent stress of NSSC

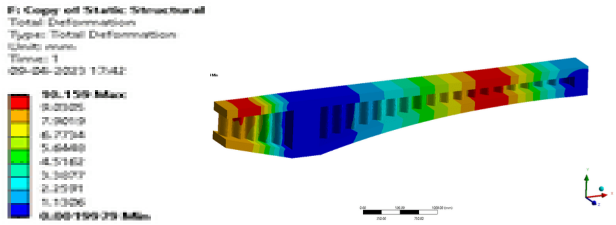

Fig. 5.4 Total deformation of NSSC

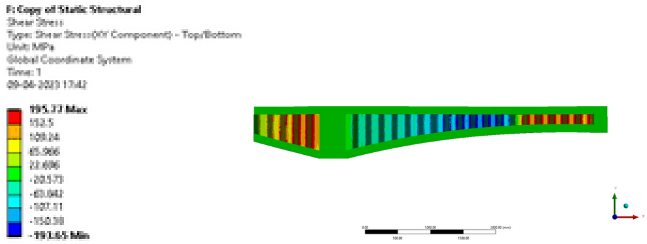

Fig. 5.5 Shear stress in steel of NSSC

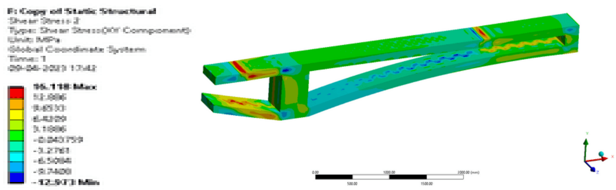

Fig. 5.6 Shear stress in concrete of NSSC

(i) Buckling analysis of non-prismatic girder with single sinusoidal corrugated steel web

Fig. 5.7 shows buckling of steel section in single sinusoidal corrugated web when displacement load is applied gradually on the top flange of non-prismatic beam.

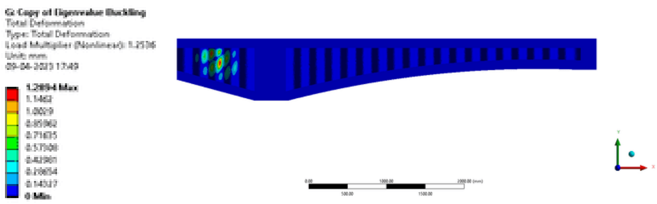

Fig. 5.7 Buckling of NSSC

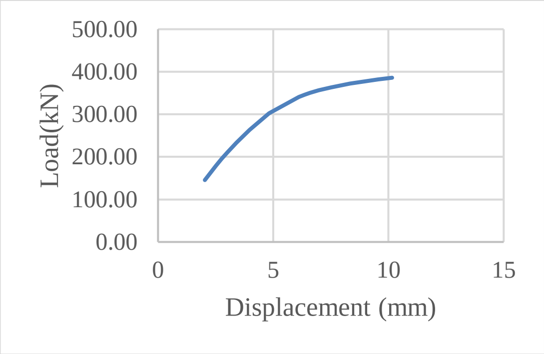

Fig. 5.8 Load-displacement graph of NSSC

Fig.5.8 shows load-displacement graph of non-prismatic beam with single sinusoidal corrugated web type. The yield load obtained is 350 kN. The below table 5.1 shows the buckling of single sinusoidal corrugated steel web. Buckling load of 368.767 kN load is more likely to buckle. So that the failure of steel will occur after the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.1: Buckling load of NSSC

Buckling Load Multiplier	Buckling Load (kN)
1.05362	368.767

5.2.2. Non-prismatic girder with single trapezoidal corrugated steel web (NSTC)

Fig. 5.9 shows meshing of non-prismatic beam with single trapezoidal corrugated steel web. Concrete and steel section is provided with mesh size of 50mm.

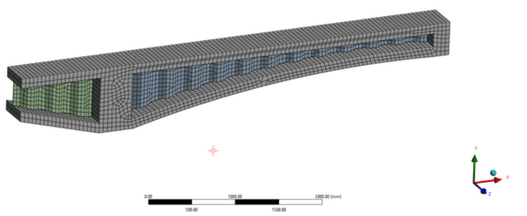

Fig. 5.9 Meshing of NSTC

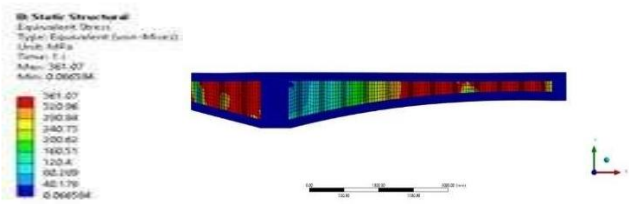

Fig. 5.10 Equivalent stress of NSTC

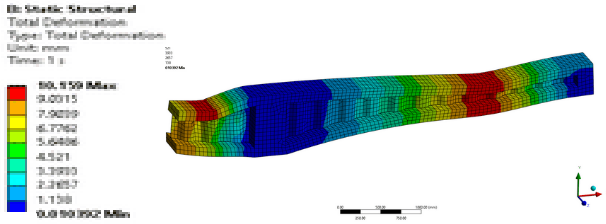

Fig. 5.11 Total deformation of NSTC

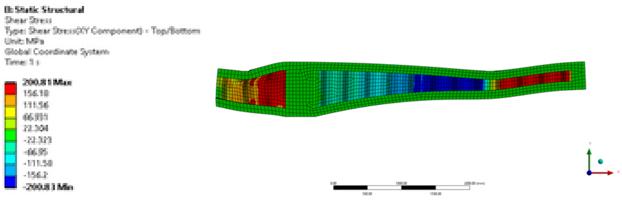

Fig. 5.12 Shear stress in steel of NSTC

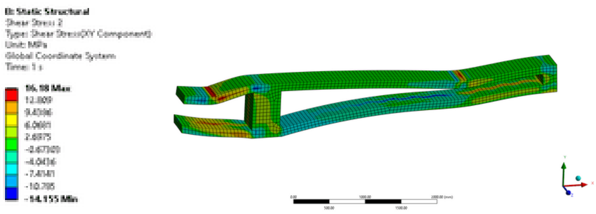

Fig. 5.13 Shear stress in concrete of NSTC

(ii) Buckling analysis of non-prismatic girder with single trapezoidal corrugated steel web

Fig. 5.14 shows buckling of steel section in single trapezoidal corrugated web when displacement load is applied gradually on the top flange of non-prismatic beam.

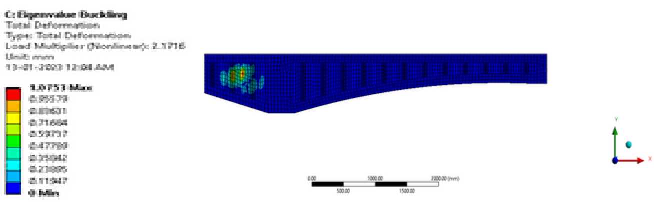

Fig. 5.14 Buckling of NSTC

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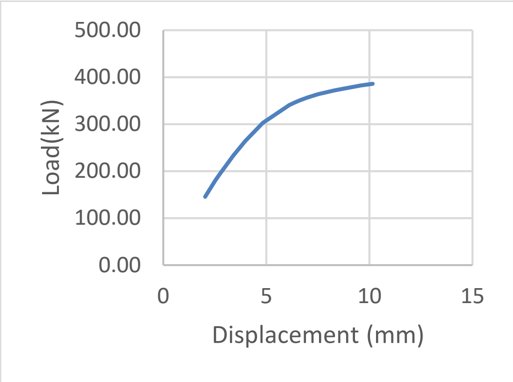

Fig. 5.15 Load-deformation graph of NSTC

Fig.5.15 shows load-displacement graph of non-prismatic beam with single trapezoidal corrugated steel web type. The yield load obtained is 340 kN. The below table 5.2 shows the buckling of single trapezoidal corrugated steel web. Buckling load of 359.312 kN load is more likely to buckle. So that the failure of steel will occur after the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.2: Buckling load of NSTC

Buckling Load Multiplier	Buckling Load (kN)
1.056	359.312

5.2.3. Non-prismatic girder with single sinusoidal corrugated steel web and stiffeners (NSSC-S)

Fig. 5.16 shows meshing of non-prismatic girder with single sinusoidal corrugated steel web and stiffeners. Concrete and steel section is provided with mesh size of 50mm.

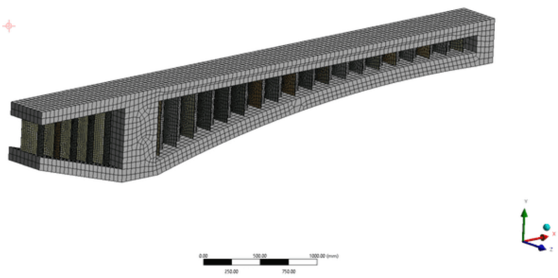

Fig. 5.16 Meshing of NSSC-S

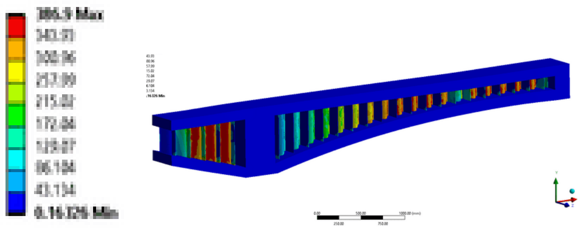

Fig. 5.17 Equivalent stress of NSSC-S

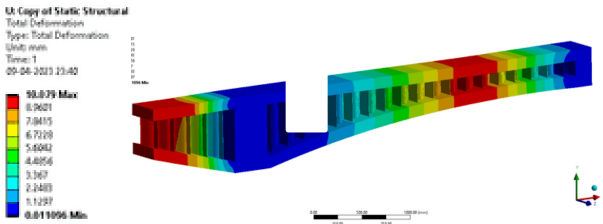

Fig. 5.18 Total deformation of NSSC-S

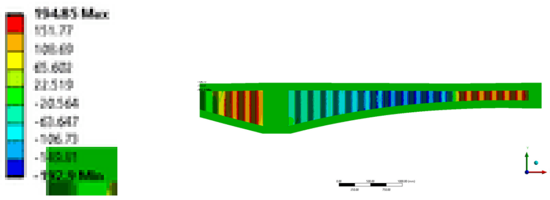

Fig. 5.19 Shear stress in steel of NSSC-S

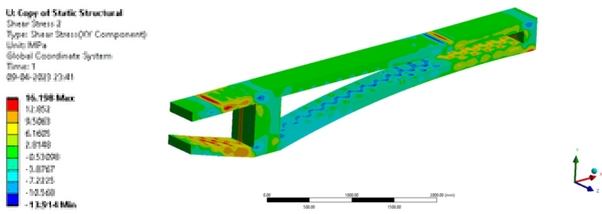

Fig. 5.20 Shear stress in concrete of NSSC-S

(iii) Buckling analysis of non-prismatic girder with single sinusoidal corrugated steel web and stiffeners

Fig. 5.21 shows buckling of steel section in single sinusoidal corrugated web and stiffeners when displacement load is applied gradually on the top flange of non-prismatic beam.

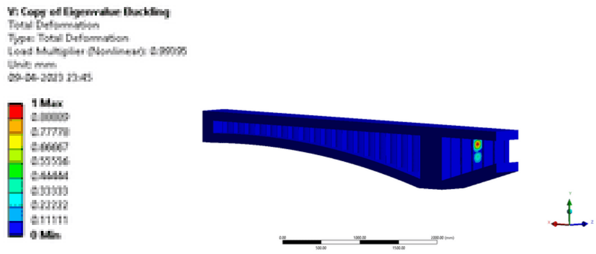

Fig. 7.21 Buckling of NSSC-S

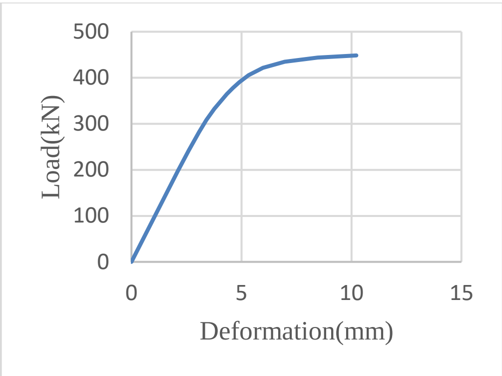

Fig. 5.22 Load-deformation graph of NSSC-S

Fig.5.22 shows load-displacement graph of non-prismatic beam with single sinusoidal corrugated steel web and stiffeners. The yield load obtained is 405 kN. The below table 5.3 shows the buckling of single sinusoidal corrugated steel web and stiffeners. Buckling load of 503. 536 kN load is more likely to buckle. So that the failure of steel will occur after the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.3: Buckling load of NSSC-S

Buckling Load Multiplier	Buckling Load (kN)
1.2433	503.536

5.2.4 Non-prismatic girder with single trapezoidal corrugated steel web and stiffeners (NSTC-S)

Fig. 5.23 shows meshing of non-prismatic girder with single trapezoidal corrugated steel web and stiffeners. Concrete and steel section is provided with mesh size of 50mm.

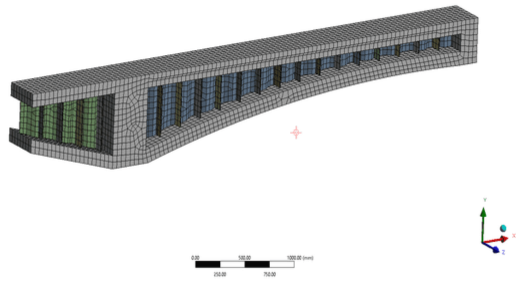

Fig. 5.23 Meshing of NSTC-S

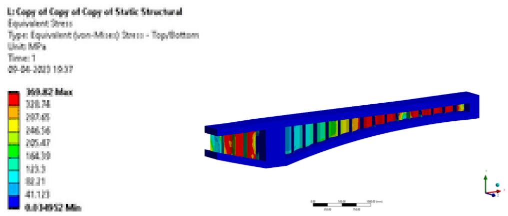

Fig. 5.24 Equivalent stress of NSTC-S

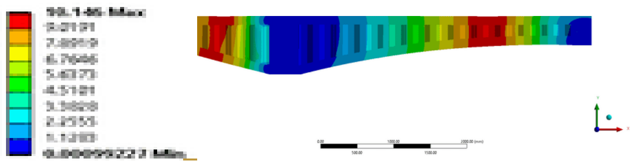

Fig. 5.25 Total deformation of NSTC-S

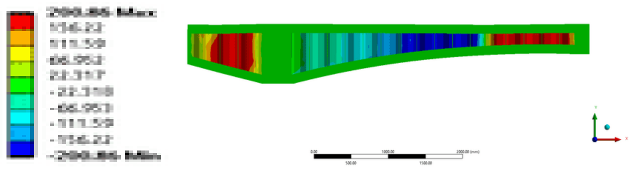

Fig. 5.26 Shear stress in steel of NSTC-S

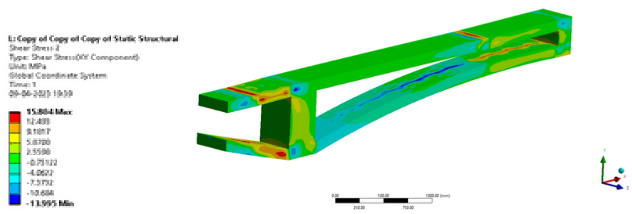

Fig. 5.27 Shear stress in concrete of NSTC-S

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(iv) Buckling analysis of non-prismatic girder with single sinusoidal corrugated steel web and stiffeners

Fig. 5.28 shows buckling of steel section in single trapezoidal corrugated web and stiffeners when displacement load is applied gradually on the top flange of non-prismatic beam.

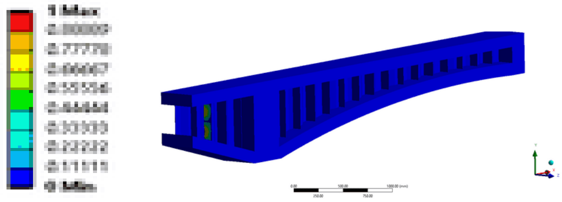

Fig. 5.28 Buckling of NSTC-S

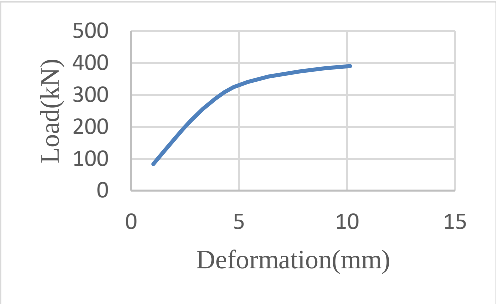

Fig.5.29 Load-deformation graph of NSTC-S

Fig.5.29 shows load-displacement graph of non-prismatic beam with single trapezoidal corrugated steel web and stiffeners. The yield load obtained is 410 kN. The below table 7.5 shows the buckling of single trapezoidal corrugated steel web and stiffeners. Buckling load of 513.976 kN load is more likely to buckle. So that the failure of steel will occur after the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.4: Buckling load of NSTC-S

Buckling Load Multiplier	Buckling Load (kN)
1.2536	513.976

5.2.5 Non-prismatic girder with double sinusoidal corrugated steel web (NDSC)

Fig. 5.30 shows meshing of non-prismatic girder with double sinusoidal corrugated steel web. Concrete and steel section is provided with mesh size of 50mm.

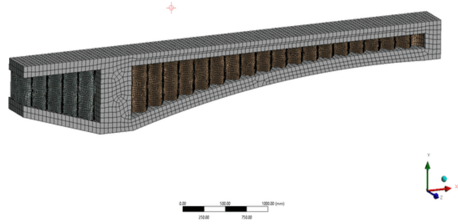

Fig. 5.30 Meshing of NDSC

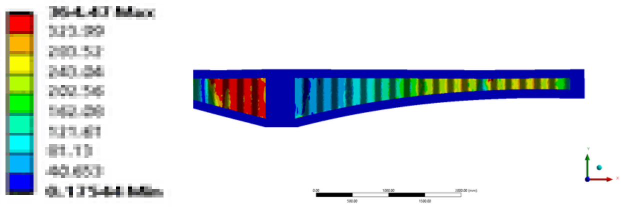

Fig. 5.31 Equivalent stress of NDSC

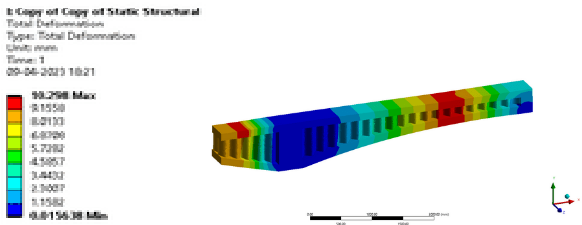

Fig. 5.32 Total deformation of NDSC

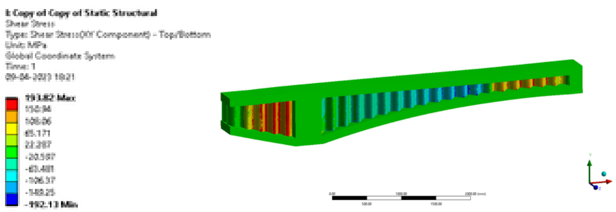

Fig. 5.33 Shear stress in steel of NDSC

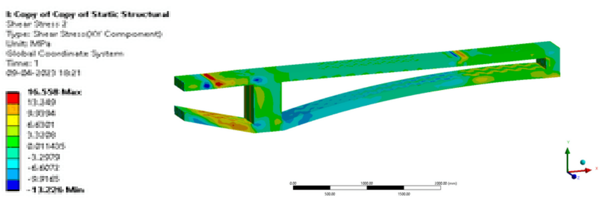

Fig. 5.34 Shear stress in concrete of NDSC

(v) Buckling analysis of non-prismatic girder with double sinusoidal corrugated steel web

Fig. 5.35 shows buckling of steel section in double sinusoidal corrugated steel web when displacement load is applied gradually on the top flange of non-prismatic beam.

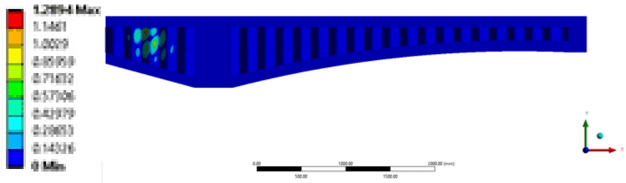

Fig. 5.35 Buckling of NDSC

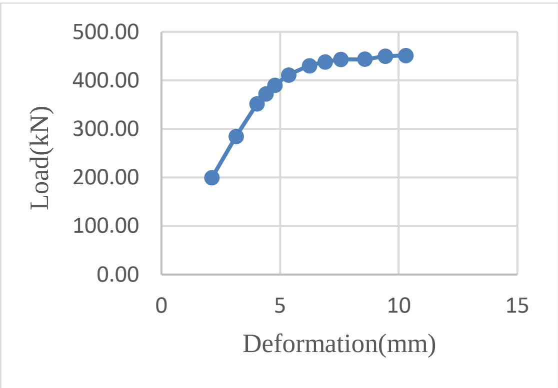

Fig. 5.36 Load-deformation graph of NDSC

Fig.5.36 shows load-displacement graph of non-prismatic beam with double sinusoidal corrugated steel web. The yield load obtained is 405 kN. The below table 5.5 shows the buckling of double sinusoidal corrugated steel web. Buckling load of 503. 536 kN load is more likely to buckle. So that the failure of steel will occur after the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.5: Buckling load of NDSC

Buckling Load Multiplier	Buckling Load (kN)
1.2433	503.536

5.2.6 Non-prismatic girder with double sinusoidal corrugated steel web and trusses (NDSC-TR)

Fig. 5.36 shows meshing of non-prismatic girder with double sinusoidal corrugated steel web. Concrete and steel section is provided with mesh size of 50mm.

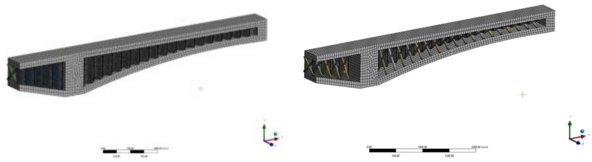

Fig. 5.37 Meshing of NSDC-TR

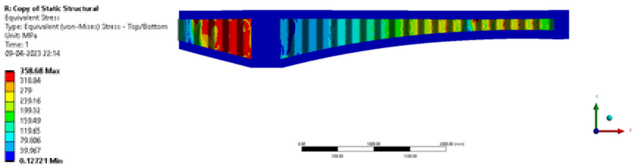

Fig.5.38 Equivalent stress of NSDC-TR

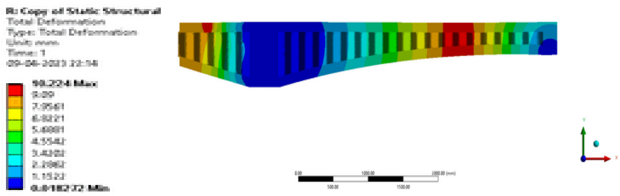

Fig.5.39 Total deformation of NSDC-TR

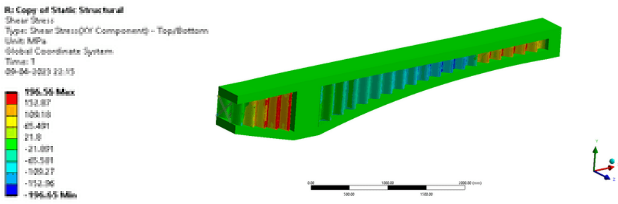

Fig. 5.40 Shear stress in steel of NSDC-TR

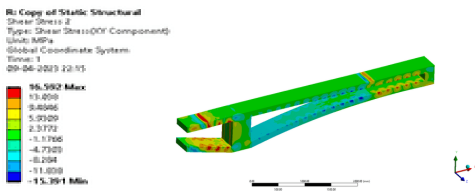

Fig. 5.41 Shear stress in concrete of NSDC-TR

(vi) Buckling analysis of non-prismatic girder with double sinusoidal corrugated steel web and truss

Fig. 5.42 shows buckling of steel section in double sinusoidal corrugated steel web and trusses when displacement load is applied gradually on the top flange of non-prismatic beam.

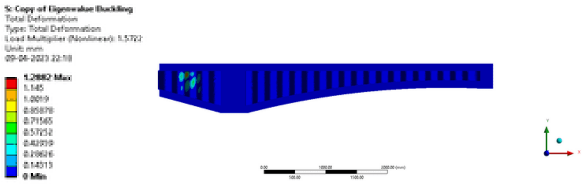

Fig. 5.42 Buckling of NSDC-TR

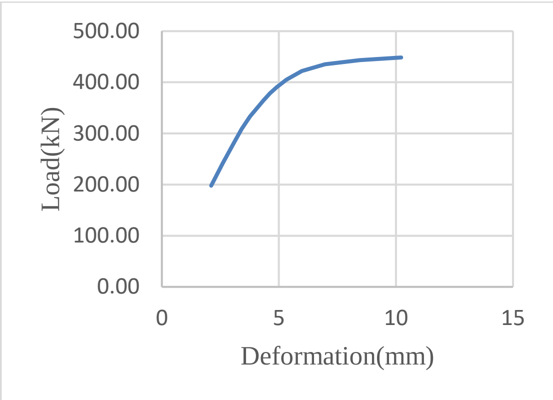

Fig. 5.43 Load-deformation graph of NSDC-TR

Fig.5.43 shows load-displacement graph of non-prismatic beam with double sinusoidal corrugated steel web connected by diagonal trusses. The yield load obtained is 420 kN. The below table 5.6 shows the buckling of double sinusoidal corrugated steel web connected by diagonal trusses. Buckling load of 660.324 kN load is more likely to buckle. So that the failure of steel will occur after the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.6: Buckling load of NSDC-TR

Buckling Load Multiplier	Buckling Load (kN)
1.5722	660.324

5.2.7 Non-prismatic girder with double sinusoidal corrugated steel web infilled with ULCC (NDSC-ULCC)

Fig. 5.44 shows meshing of non-prismatic girder with double sinusoidal corrugated steel web. Meshing of steel and concrete section are cleary shown on figure Concrete and steel section is provided with mesh size of 50mm.

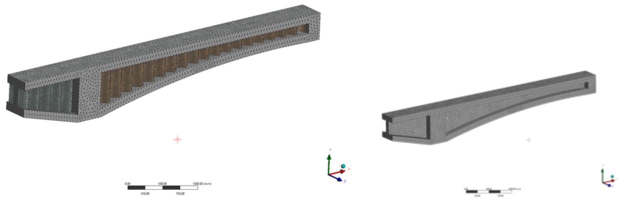

Fig. 5.44 Meshing of NDSC-ULCC

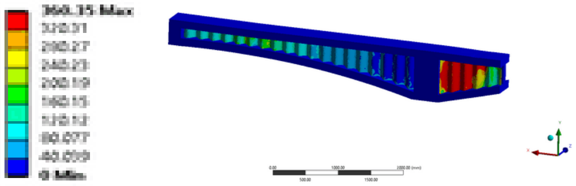

Fig. 5.45 Equivalent stress of NDSC-ULCC

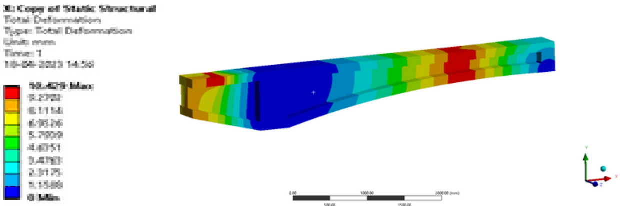

Fig. 5.46 Total deformation of NDSC-ULCC

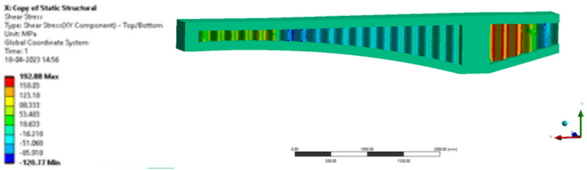

Fig. 5.47 Shear stress in steel of NDSC-ULCC

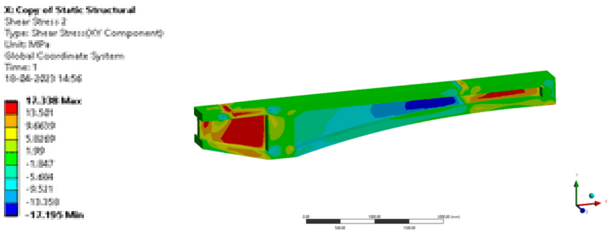

Fig. 5.48 Shear stress in concrete of NDSC-ULCC

(viii) Buckling analysis of non-prismatic girder with double sinusoidal corrugated steel web infilled with ULCC

Fig. 5.49 shows buckling of steel section in double sinusoidal corrugated steel web infilled with ULCC when displacement load is applied gradually on the top flange of non-prismatic beam.

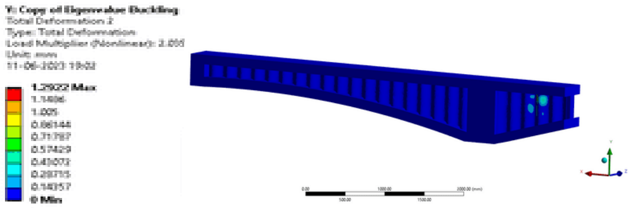

Fig.7.49 Buckling of NDSC-ULCC

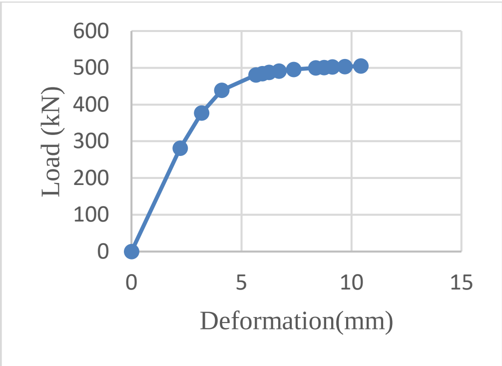

Fig. 5.50 Load-deformation graph of NDSC-ULCC

Fig.5.50 shows load-displacement graph of non-prismatic beam with double sinusoidal corrugated steel web infilled with ULCC. The yield load obtained is 491 kN. The below table 5.7 shows the buckling of double sinusoidal corrugated steel web infilled with ULCC. Buckling load of 817.68 kN load is more likely to buckle. So that the failure of steel will occur after the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.7: Buckling load of NSDC-ULCC

Buckling Load Multiplier	Buckling Load (kN)
1.7035	817.68

5.2.8 Non-prismatic girder with steel grid (NG)

Fig. 5.51 shows meshing of non-prismatic girder with steel grid. Concrete and steel section is provided with mesh size of 50mm.

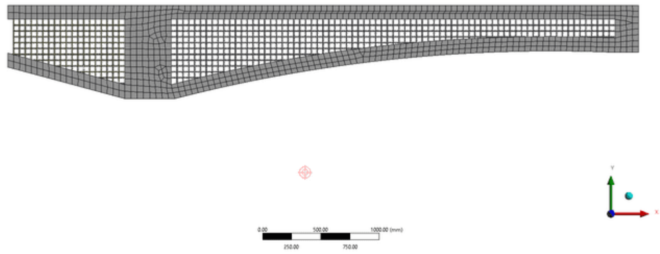

Fig. 7.51 Meshing of NG

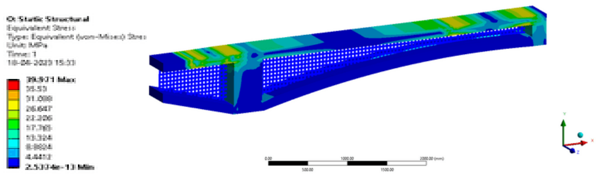

Fig. 5.52 Equivalent stress of NG

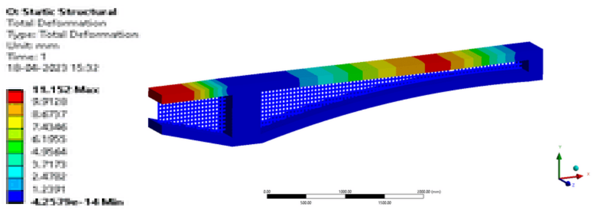

Fig. 5.53 Total deformation of NG

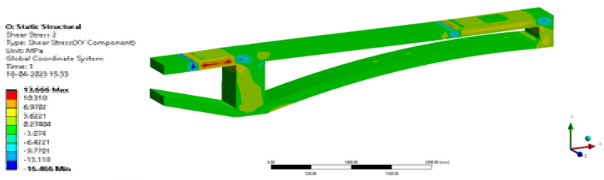

Fig. 5.54 Shear stress in concrete of NG

(viii) Buckling analysis of non-prismatic beam with steel grid

Fig. 7.54 shows buckling of steel grid when displacement load is applied gradually on the top flange of non-prismatic beam.

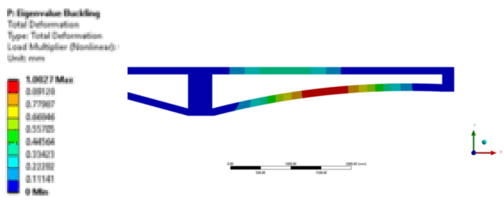

Fig. 5.55 Buckling of NG

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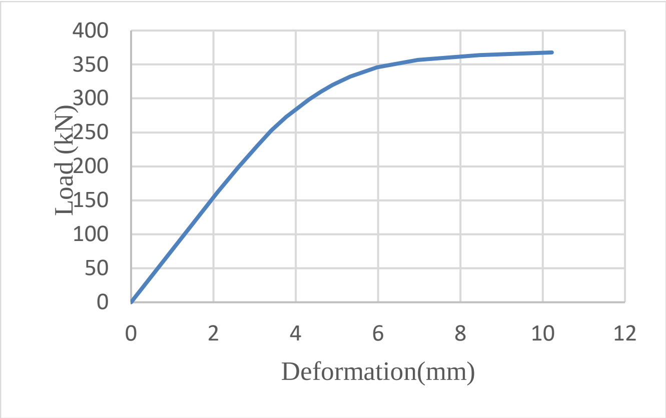

Fig. 5.56 Load-deformation graph of NG

Fig.5.56 shows load-displacement graph of non-prismatic girder with steel grid. The yield load obtained is 310 kN. The below table 5.8 shows the buckling of non-prismatic girder with steel grid. Buckling load of 817.68 kN load is more likely to buckle. So that the steel section buckles earlier than the yielding of concrete.

Yield load x Buckling load multiplier = Buckling load

Table 5.8: Buckling load of NG

Buckling Load Multiplier	**Buckling Load (kN)**
10.41574	128.8794

6. RESULTS AND DISCUSSION

The analysis was done in order to find out the load bearing capacity, buckling strength and shear stress by adding additional materials in the web and change in corrugations. From the above analysis it is evident that by changing the corrugations and adding materials in the web , the load carrying capacity is improved. From this it analysed that double sinusoidal with concrete infill is better. The result of the above analysis concluded below:

6.2 RESULTS

The below graph 6.1. shows the load-displacement graph of each models.

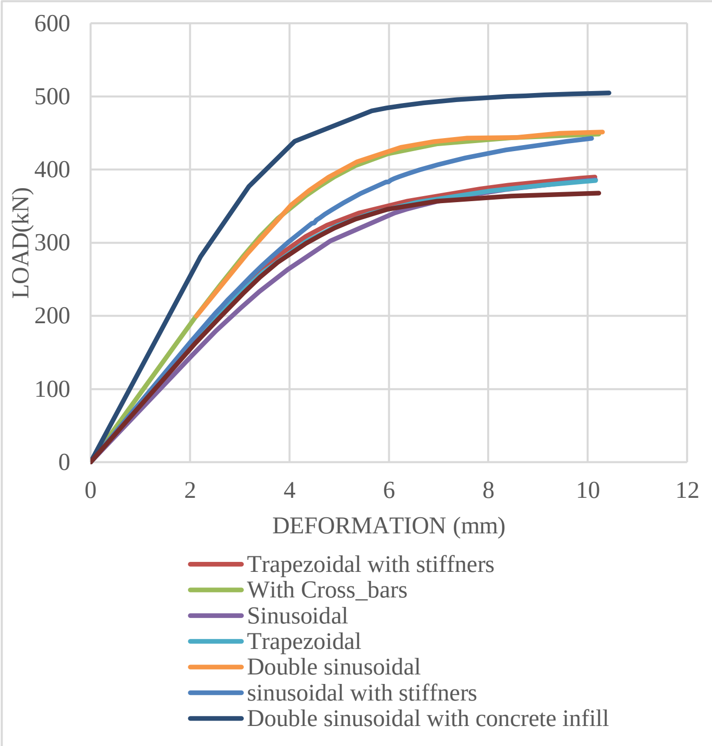

Fig. 6.1 Load-displacement graph

The below table .1. shows the result of load bearing capacity and buckling load in the model when the different corrugation methods were used.

Table 6.1: Result comparison

Model	Load bearing capacity(kN)	Buckling load(kN)
Single sinusoidal type	350	368.767
Single trapezoidal type	340	359.312
Sinusoidal with stiffeners type	405	402.549
Trapezoidal with stiffeners	370	389.700
Double sinusoidal type	410	513.976
Double sinusoidal with truss	420	660.324
Double sinusoidal with concrete infill type	491	817.68
Non prismatic beam with steel grid	310	128.879

Here non-prismatic beam with double sinusoidal with infilled concrete structure possess better load bearing capacity and buckling load. It has 15% more load carrying capacity than double sinusoidal with trusses. Non-prismatic beam with steel grid having diameter 10mm is less efficient to bear heavy load and low buckling strength.

Table 6.2: Comparison of sinusoidal and trapezoidal corrugated steel web

Model	Load bearing capacity(kN)	Buckling load(kN)
Single sinusoidal type	350	368.767
Single trapezoidal type	340	359.312
Sinusoidal with stiffeners	405	402.549
Trapezoidal with stiffeners	370	389.700

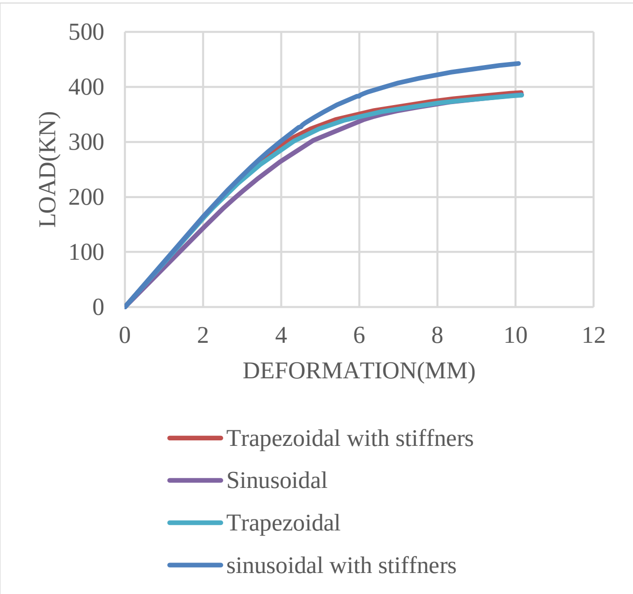

Fig. 6.2 Comparison of sinusoidal and trapezoidal corrugated steel web

Non-prismatic beam with single sinusoidal corrugated steel web with stiffeners having increased load bearing capacity and buckling load. By adding stiffeners in trapezoidal section resulting decrement in the load bearing capacity. Sinusoidal corrugation shows better performance than trapezoidal corrugation.

Table 6.3: Comparison of single sinusoidal and double sinusoidal corrugated web

Model	Load bearing capacity(kN)	Buckling load(kN)
Single sinusoidal type	350	438.76
Sinusoidal with stiffeners type	405	402.549
Double sinusoidal type	410	513.976
Double sinusoidal with truss	420	660.324
Double sinusoidal with concrete infill type	491	817.68

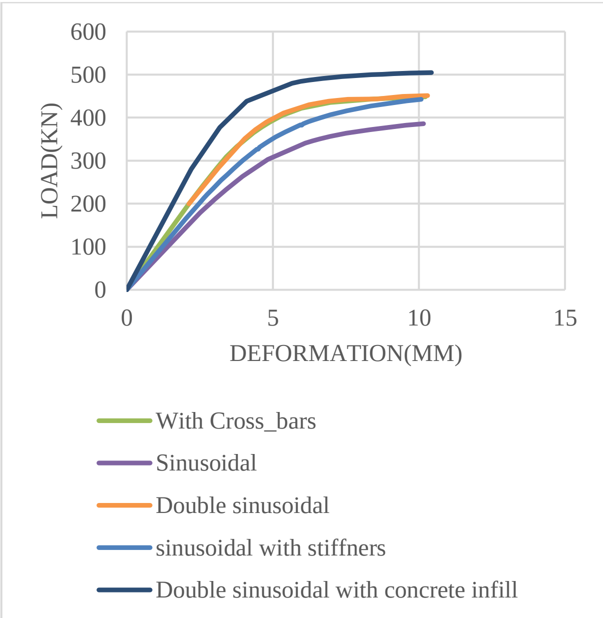

Fig. 6.3 Comparison of single sinusoidal and double sinusoidal corrugated web

Load bearing capacity of the girder by adding light weight concrete in between double sinusoidal corrugated web has higher load bearing capacity. About 32 percent improvement of load carrying capacity can be observed here. Adding trusses in between sinusoidal web was resulted in 29 percent increment of load carrying capacity than that of providing stiffeners. By adding stiffeners at particular interval in sinusoidal corrugated section resulted in 10 percent decrement in load bearing capacity.

7. CONCLUSION

The strengthening of corrugated web by means of providing stiffeners, truss or by making the web portion as a composite one using a composite material and steel grid was investigated analytically in this paper. The comparison on the effect of single sinusoidal and double sinusoidal and also compare sinusoidal and trapezoidal corrugations was also analysed. The following conclusions are derived from this present paper:

- For both sinusoidal and trapezoidal , the load carrying capacity and strength of Non - prismatic girders affected by providing additional material in the corrugated web. Load-carrying capacity was observed to be improved slightly with the change in the shape of steel corrugated web of the non-prismatic girder
- The strength and load carrying capacity of Non-prismatic girders with Double corrugated web can be improved by providing ultra light weight concrete in between the double sinusoidal corrugated webs
- The rate of improvement of strength is excellent for composite web than that of stiffened steel web and trusses
- Adding stiffened steel in sinusoidal corrugated web has 16 percent more load bearing capacity than stiffened steel in trapezoidal corrugated steel web. But adding stiffeners in trapezoidal corrugated web results 10 percent decrement in load bearing capacity
- Double sinusoidal with diagonal truss has 4 percent more strength than double sinusoidal corrugated steel webs
- By adding steel grid shows very poor performance in strength and stability. Because steel grid did not carry shear stress. So the shear stress fully affect on the concrete section and damage occurs
- The shear buckling of the tapered steel corrugated webs occurred in the cantilever side at a certain distance from the support, where the average shear stress in the steel corrugated webs reached a maximum value, causing the steel sheet to buckle
- This finding shows that the support cross section was not the critical shear section in the structural design of a non-prismatic beam with steel corrugated webs
- The concrete slabs became seriously cracked and damaged in response to the shear buckling of the steel corrugated webs. The damage to the concrete slabs was another particularly important factor affecting the ultimate load carrying capacity of a non-prismatic beam with concrete slabs and steel corrugated webs
- Double sinusoidal with concrete infill type has more buckling strength and it leads to less damage in the concrete section
- The ultimate shear buckling load is 817.68kN
- The double sinusoidal corrugated web in girders with ULCC filled section showed highest load carrying capacity and strength than that of other Structures

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