FLEXURAL BEHAVIOUR OF CORRUGATED BEAM ANALYSIS BY ABAQUS AND EXPERIMENTAL

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ABSTRACT

Built-up sections are widely used in cold formed thin-walled steel frames. This projects mainly investigates behaviour of cold-formed steel (CFS) lipped channel corrugated section beams. This paper discuss the response of cold formed steel (CFS) lipped channel corrugated section beams (i) horizontal corrugated back to back lipped channel sections without gap (ii) horizontal corrugated back to back lipped channel sections with gap (iii) vertical corrugated lipped channel sections by providing corrugation angle in horizontal and vertical. The finite element method is used to solve the buckling of steel beams. Experimental setup will be made to find the load versus deflection behaviour under flexure and study the various modes of failure.Totally 9 specimens are taken for the testing by vertical two point loading with simply supported condition. Finally experimental results are compared with the finite element analysis.

Keywords : CFS(Cold-formed steel), horizontal corrugation, vertical corrugation, finite element analysis, flexural behaviour.

1.INTRODUCTION

1.1GENERAL

Cold-formedsteel(CFS)istypeofsteelfabricatedbycoldformingprocess.CFS membershavebeenusedinbuildings,bridges,storageracks,grainbins,carbodies, railwaycoaches,highwayproducts,transmissiontowers,transmissionpoles,drainage products,transmissiontowers,transmissionpoles,drainagefacilities,varioustypesof equipmentandothers..TheASD Specificationwassubsequentlyrevisedin1956,1960,1962,1968,1980,and1986to reflectthetechnicaldevelopmentsandtheresultsofcontinuedresearchatCornelland otheruniversities(Yuetal.,1996).In1991,AISIpublishedthefirsteditionoftheLoad andResistanceFactorDesignSpecificationdevelopedatUniversityofMissouriof RollaandWashingtonUniversityunderthedirectionsofWei-WenYuandTheodore V.Galambos(AISI,1991).BothASDandLRFDSpecificationswerecombinedintoa singlespecificationin1996(AISI,1996).PastresearchersinvestigatedonI-girderswithtrapezoidalcorrugationofhot rolledsection.Theuseofcorrugatedwebsisapotentialmethodtoachieveadequate out-of-planestiffnessandshearbucklingresistancewithoutusingstiffeners;therefore, itconsiderablyreducesthecostofbeamfabricationandtheweightsofsuperstructures. Becausethecorrugatedwebcarriesonlyshearforcesandtheflangescarrythemoment duetotheaccordioneffect.Inordertobenefitfromthesecharacteristics,prestressed concreteboxgirderbridgeswithcorrugatedwebsareusedextensively.Shearstresses cancausethefailureofthewebbyshearbucklingoryieldingdependingonthe geometriccharacteristicsofthecorrugatedwebs.Therefore,moststudiesoncorrugated websarerestrictedtotheshearbucklingofcorrugatedwebs.Recently,several researchershaveattemptedtousecorrugatedplatesinthewebs.Thiscanovercomethe disadvantagesofconventionalstiffenedflatwebssuchaswebinstabilityduetobending stressandfatiguefailure.

1.2ADVANTAGESOFCOLDFORMEDSTEEL

1.Ascomparedwiththickerhot-rolledshapes,cold-formedlightmemberscan bemanufacturedforrelativelylightloadsand/orshortspans.

2.Unusualsectionalconfigurationscanbeproducedeconomicallybycold-formingoperationsandconsequentlyfavorablestrength-to-weightratioscan beobtained.

3.Nestablesectionscanbeproduced,allowingforcompactpackagingandshipping.

1.3OBJECTIVEOFTHEPROJECT

1.Toevaluatethebendingresistanceofcold-formedcorrugatedsection subjectedtoflexure.

2.Tostudythevariousmodesoffailure.

3.Tocomparethesoftwareandexperimentalresults.

4.Toanalysistheloadversusdeflectionbehaviourunderflexure.

2. MATERIALSPECIFICATION

Beam-2(horizontalcorrugationwithSpacing)

Depthofthebeam =190mm

Widthofthebeam(flange) =165mm

Lipofthesection =25mm

Lengthofthespecimen =1200mm

Thickness =2.5mm

Spacing =25mm

Beam-3(verticalcorrugation)

Depthofthebeam =190mm

Widthofthebeam(flange) =140mm

Lipofthesection =25mm

Lengthofthespecimen =1200mm

Thickness =2.5mm

Plate

Lengthoftheplate =1200mm

Width(forbeam-1) =140mm

Width(forbeam-2) =165mm.

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2.1SPECIMENDETAILS

2.2HORIZONTALCORRUGATIONWITHOUTSPACING

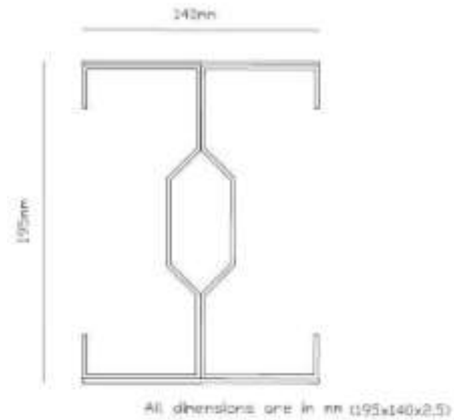

Fig3.1.HorizontalCorrugationWithoutSpacing**2.3 HorizontalCorrugationWithSpacing**

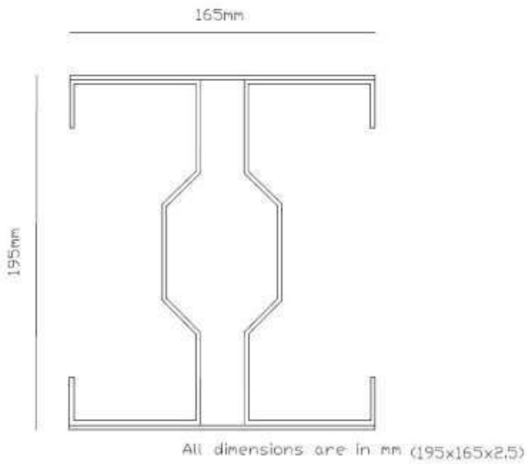

Fig3.2.HorizontalCorrugationWithSpacing

2.4 VerticalCorrguation

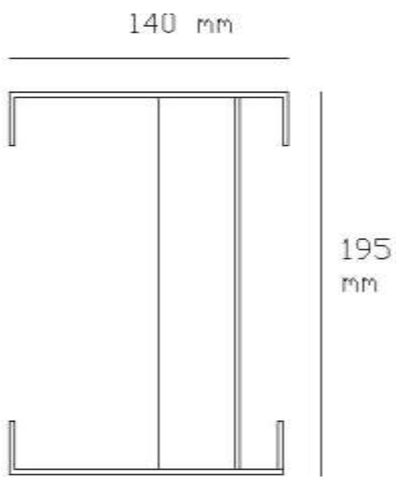

Fig3.3.VerticalCorrguation

3. SoftwareAnalysis

Everycompletefinite-elementanalysisconsistsof3separatestages:

- Pre-processingormodelling:Thisstageinvolvescreatinganinputfilewhich containsanengineer'sdesignforafinite-elementanalyzer(alsocalled"solver").
- Processingorfiniteelementanalysis:Thisstageproducesanoutputvisualfile.
- Post-processingorgeneratingreport,image,animation,etc.fromtheoutputfile: Thisstageisavisualrenderingstage

3.1 SECTIONALSPECIFICATION

BacktoBackbuilt-upchannellippedcorrugatedsectionbeamshasbeen selected.Twospecimensweretakenwithdifferentcrosssectionproperties.They arediscussedbeforeandanalysisarecarriedoutbelow.

- **ChannelDimensions**

Depth=190mm

Width(flange)=70mm

Span=1200mm

Thickness=2.5mm

Spacing=0mmand25mm

Platedimensions=140x2.5mmand165x2.5mm

3.2 MODELLING

ModellinghasbeendoneinABAQUS6.12.3Dbeammodelispreparedby ABAQUS.

MaterialProperty

1. Density of steel (δ_s) : 0.000000785 N/mm^3
2. Poissons's Ratio (μ) : 0.3
3. Young's modulus of steel (E_s) : 203395.33 Mpa

3.3 LoadingPatternForHcwosBeam

Twopointloadinghasbeengiventothemodel.Theloadsareplacedat1/3 distancefromthesupport.

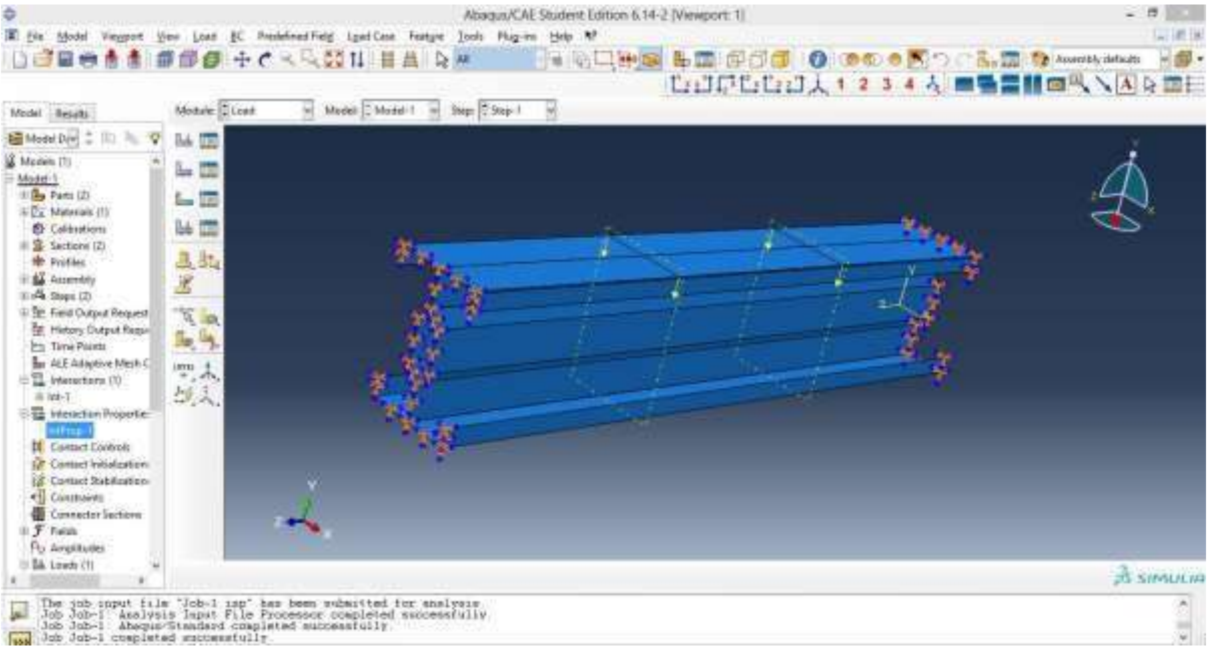

Fig.3.1Loadingarrangementofthebeam

3.4 FAILUREPATTERNFORHCWOSBEAM

Thevariousiterationshavebeengiventothebeam-1andmaximumloadby whichthebeamdeflectsisfound.Fig5.2showsthefailurepatternofbeam-1.

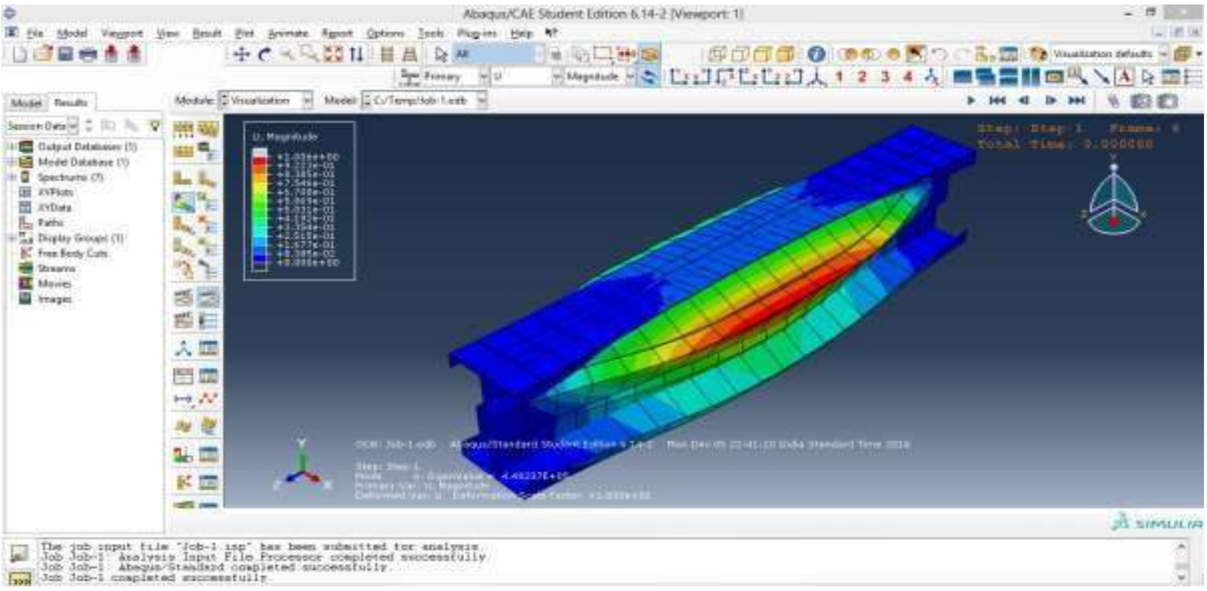

Fig.3.2LoadingarrangementoftheHCWOSbeam

3.5LoadingPatternForHcwsBeam

Twopointloadinghasbeengiventothemodel.Theloadsareplacedat1/3 distancefromthesupport.

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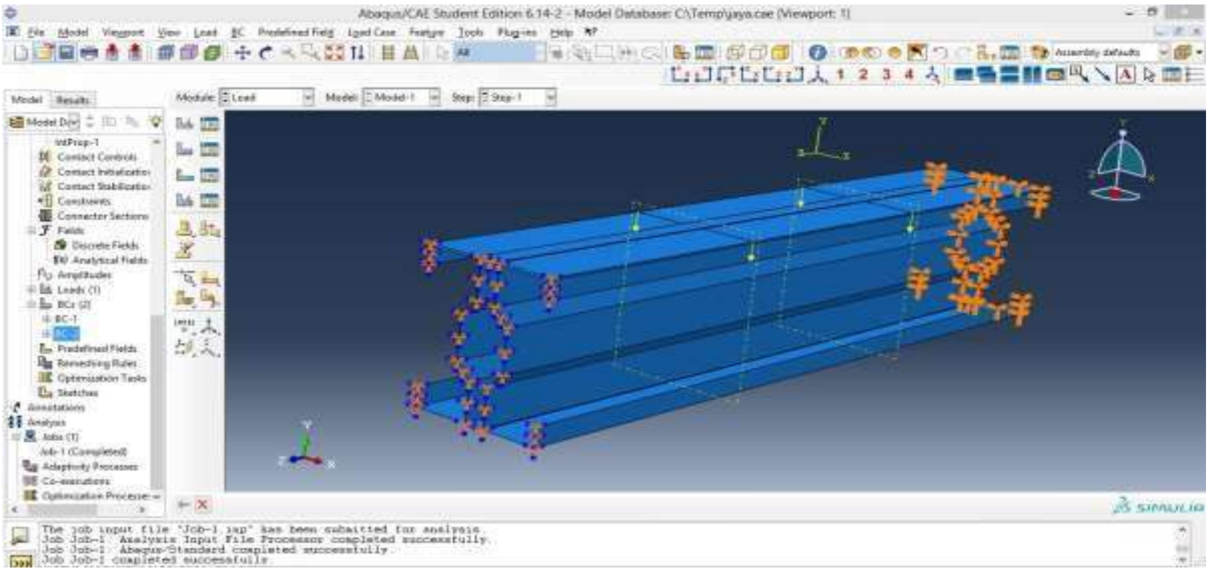

Fig.3.3LoadingarrangementoftheHCWSbeam

3.6FailurePatternForHcwsBeam

Thevariousiterationshavebeengiventothebeamandmaximumloadbywhich thebeamdeflectsisfound.Fig5.2showsthefailurepatternofbeam-2.

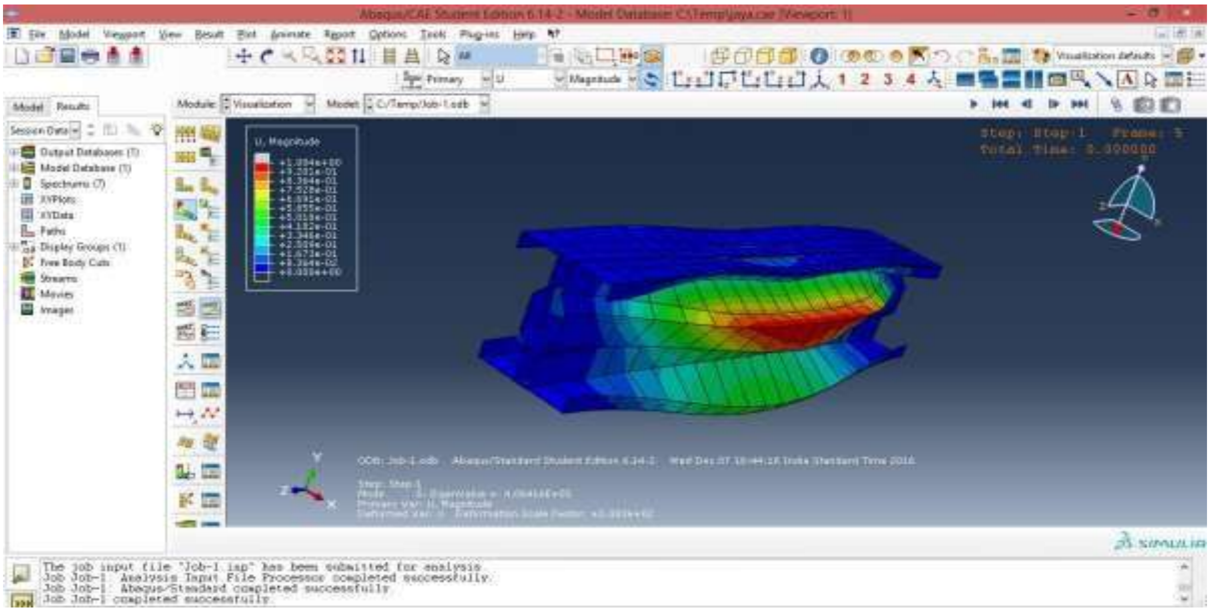

Fig.3.4LoadingarrangementoftheHCWSbeam

3.7LoadingPatternForVcBeam

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Twopointloadinghasbeengiventothemodel.Theloadsareplacedat1/3 distancefromthesupport.

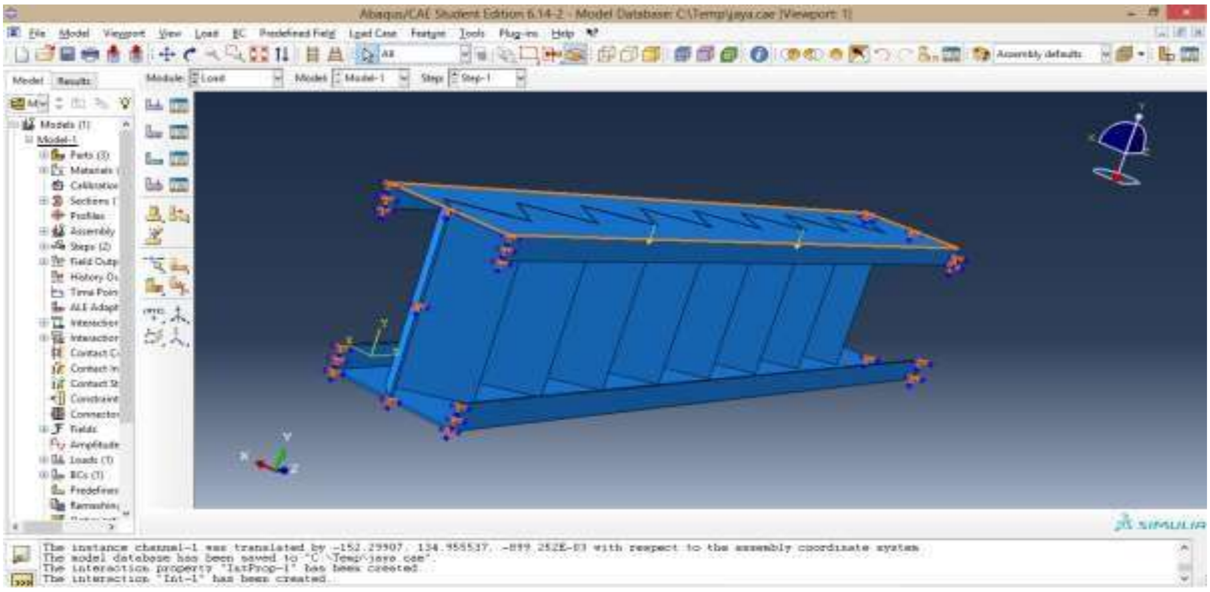

Fig.3.5LoadingarrangementoftheVCbeam

3.8FailurePatternForVcBeam

Thevariousiterationshavebeengiventothebeamandmaximumloadbywhich thebeamdeflectsisfound.Fig5.2showsthefailurepatternofbeam-2.

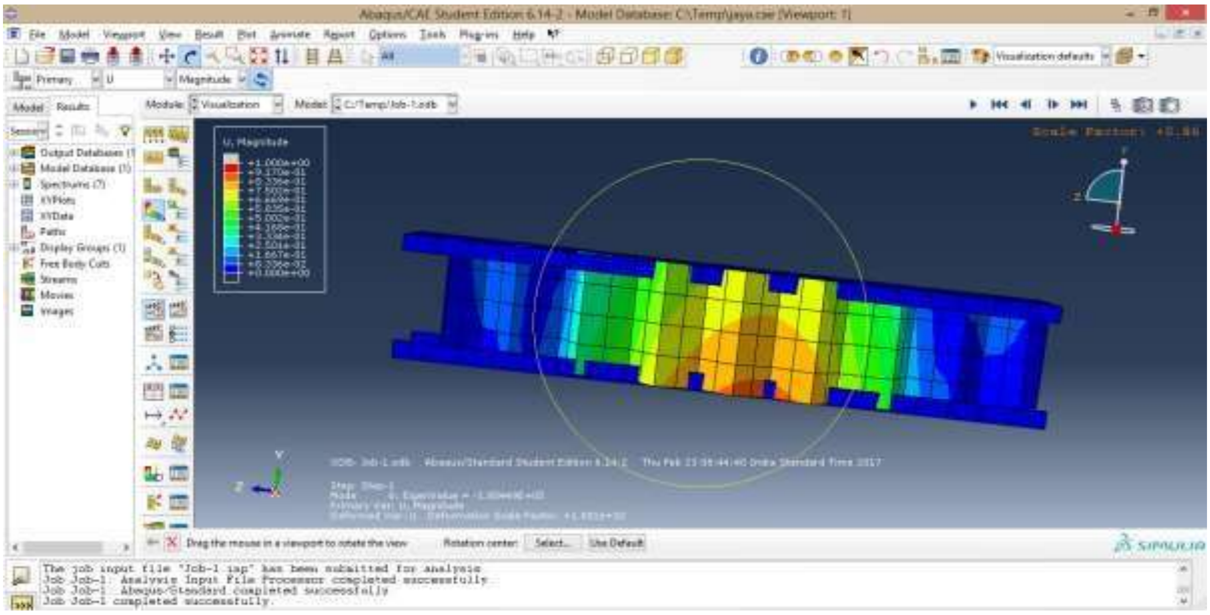

Fig.3.7LoadingarrangementoftheVCbeam

3.9SOFTWARERESULT

ThebeammodelcreatedinABAQUS.Table4.1showsthemaximum deflectionsvalueforthedifferentmaterialandmethod.Fig5.2,5.4and5.6showsanalyticalresultsforthebuilt-upCorrugationsection ofsimplysupportedcondition.Theresultshowsdisplacementbehaviour,stress behaviourandfailuremodes.

Table3.1MaximumDeflectionValueofBeammodel

MODEL	MATERIAL	Ultimate load (KN)	DEFLECTION(mm)
Beam -1	Cold-formed Steel	29	4.2
Beam -2	Cold-formed Steel	14	3.98
Beam -3	Cold-formed Steel	41	3.63

4.INVESTIGATION

4.1 TESTSPECIMENDETAILS

Thetestspecimensconsistofcold-formedsteelbeamswith1,horizontal corrugationwithspacing,2,horizontalcorrugationwithoutspacing3,vertical corrugation.Thespanofthebeamwas1200mmandthecrosssectionsofthebeams are195mmx140mmx2.5mm.Theyieldstrengthofsteelusedis380N/mm^2 .The cold-formedsteelbeamisbuiltupbyweldingtheflangesandthewebusingintermittent weldsof6mmthickness.Abeamwasprovidedatboththeloadpointstominimizelocal effectduetoconcentratedloads.

Fig4.1TestSpecimen

4.2TestSetup

Thetestingwascarriedoutinaloadingframeof400kNcapacity.Allthe specimensweretestedforflexuralstrengthundertwopointloading.Thespecimens werearrangedwithsimplysupportedconditionshavinganeffectivespanof1.2m. Loadswereappliedatone-thirddistancefromthesupportsatauniformratetillthe ultimatefailureofthespecimensoccurred.Beamdeflectionsweremeasuredatseveral locationsusingLinearVariableDisplacementTransducers(LVDTs)asshowninthe Figure6.2.StraingaugesandLVDTswereconnectedtoadataloggerfromwhichthe readingswerecapturedbyacomputerateveryloadintervalsuntilfailureofthebeam occurred.Theexperimentalset-upforthetestspecimensareshowninFigure6.2.

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Fig4.2Experimentalset-upforthetestspecimens

4.3RESULTSANDDISCUSSIONS

Allthespecimenweretestedforflexuralstrengthundertwopointloadingby usingreactiontypemovableloadingframesDeflectionandstrainreadingsareobserved fromDATAlogger.Thefollowingobservationsweremadeduringtheprogressofthe tests.Theobservationsaresummarizedinthefollowing.

4.4 FAILUREPATTERNOFBEAMS

Fig4.3FailureofHCWOSbeam

Fig4.4FailureofHCWSbeam

Fig4.5FailureofVCbeam

4.5LOADSANDDEFLECTIONOFTHEHCWOSSPECIMENS

Table4.1LoadandDeflectionofHCWOSspecimens

S.NO	LOAD(KN)	DEF(mm) -1	DEF(mm) -2	DEF(mm) -3
1	0	0	0	0
2	3	0.33	0.49	0.45
3	6	1.28	1.49	1.44
4	9	1.98	2.25	2.19
5	12	2.34	2.63	2.56
6	15	2.56	2.9	2.86
7	18	3.2	3.65	3.6
8	21	3.78	4.59	4.53
9	24	5.12	5.43	5.39

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10	27	5.98	6.19	6.13
11	30	6.32	6.39	6.35
12	33	6.4	6.47	6.4

Fig 4.6 Load v/s deflection graph for HCWOS beam specimen 1

Fig 4.7 Load v/s deflection graph for HCWOS beam specimen 2

Fig 4.8 Load deflection graph v/s for HCWOS beam specimen 3

5.CONCLUSION

The main objective of the project was successfully accomplished. From the experimental investigations carried out to study the flexural behaviour of cold-formed corrugated web beams.From the results vertical corrugation obtain a high resistance to lateral buckling and corrugation acts as a stiffener for the beam.Cold-formed section with horizontal and vertical corrugation has resulted in increased resistance to lateral-buckling.Horizontal corrugation without spacing is obtained a load 7% higher than the with spacing and vertical corrugation is obtained a load about 17% and 10% higher than horizontal corrugation without and with spacing respectively.

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