iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VIII **Month of publication:** Aug 2023

DOI: https://doi.org/10.22214/ijraset.2023.55365

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

Numerical and Experimental Investigation on the Structural Behavior of Laterally Restrained Cold Formed Steel Built-Up Sigma Section

P. Kamal[1], M. Sivagami[2], Dr. R. Thenmozhi[3]
[1]M.E. Structural Engineering, Department of Civil Engineering, Government College of Technology-Coimbatore
[2]Research Scholar, Department of Civil Engineering, Government College of Technology-Coimbatore
[3]Professor and Head of the Department, Department of Civil Engineering, Government College of Technology-Coimbatore

Abstract: This study focused on the structural behavior of laterally restrained Cold Formed Steel (CFS) built up Beam composed of two Sigma Section which are placed back-to-back with varying thickness, aspect ratio and yield stress. It's aimed to create accurate Finite Element Model for CFS built up I beam.

The numerical model was developed by using Finite Element (FE) software ABAQUS 6.13. The numerical investigation was checked and validated with help of experimental investigation. The load carrying capacity increases with increase in height and the thickness of the specimen.

The specific strength decreases with increase in the height of the specimen. The specific strength of the specimen increases with increases in thickness.

The local Buckling plays an important role in the Specific Strength of the Section. It's essential to provide Vertical flange stiffener for resisting the local Buckling in order to achieve the full capacity of the section.

Keywords: Cold Formed Steel (CFS), Built up section, ABAQUS, Direct Strength Method, Sigma Section, Local Buckling.

I. INTRODUCTION

The two main categories of structural members used in steel building are hot-rolled steel forms and cold-formed steel shapes. Cold-formed steel is a type of steel that is produced at room temperature as opposed to hot-rolled steel, which is formed at high temperatures. structural members made of cold-formed steel (CFS), which are less common but more significant. Common applications for cold-formed steel members include purlins, cladding rails, sheeting rails, wall studs, floor joists, sheets, and decks. They offer a significantly higher strength to weight ratio compared to thicker hot rolled members.

There are many different product shapes on the market, and C and Z sections are frequently utilized in light load and medium span situations, such as roof systems.

The method of cold forming points at the process of metal forming in which the shape and structure of steel is being changed by drawing, extruding, hammering, pressing, spinning or stretching at temperatures below the steel's recrystallization 2 temperature. These actions create alterations in the metal's work which increase its hardness and tensile strength while enhancing the surface finish.

The general name for them is Cold Formed Steel Sections. They may also be known by the names Cold Rolled Steel Sections or Light Gauge Steel Sections. Steel sheets used in cold-formed construction typically range in thickness from 0.4 to 3 mm. The method of manufacturing is important as it differentiates these products from Hot Rolled Steel sections. It is obvious that thinner the section walls, the larger will be the corresponding moment of inertia values (Ixx and Iyy) and hence capable of resisting greater bending moments. The consequent reduction in the weight of steel in general applications produces economies both in steel costs as well as in the costs of handling transportation and erection. This indeed, is one of the main reasons for the popularity and the consequent growth in the use of cold rolled steel. Also, cold formed steel is protected against corrosion by proper galvanizing or powder coating in the factory itself.

II. GEOMETRIC DETAILS

The width of the sections was fixed and the height and thickness are varied accordingly. Other geometric parameters such as lip, span was kept constant. height increased to aspect ratios of 3,4 and 5. Two different thickness are used 1.6mm and 2mm. Three Parameters are varied i.e. (yield Strength, Aspect Ratio, Thickness).

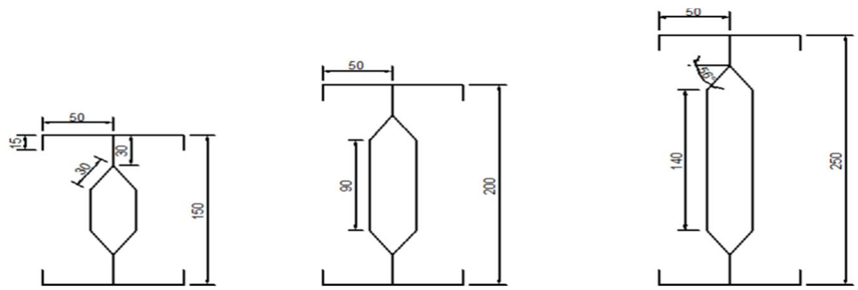


Figure 1 Cross Sectional Details

III. NUMERICAL INVESTIGATION

A. General

Numerical Analysis was carried out using Finite Element software ABAQUS version 6.13. It is used to simulate the CFS built-up beams.

B. Finite element type

The widely adopted four-noded shell element S4R with six degrees of freedom for each node. This element type has been successfully used by researchers in numerical modelling of cold-formed steel built-up sections. An element size of 25 × 25 mm was adopted.

C. Material properties

Table 1 Specimen Details

Specimen	*Aspect Ratio*	*Yield Strength (N/mm²)*	*Size HXBXDXT mm*
S1	3	345	150X50X15X1.6
S2			150X50X15X2
S3	4		200X50X15X1.6
S4			200X50X15X2
S5	5		250X50X15X1.6
S6			250X50X15X2

For the numerical analysis, the ABAQUS Software requires input of the material stress-strain curves in the form of true stress (σtrue) versus true plastic strain (εtrue). The true stress (σtrue) and true plastic strain (εtrue) are calculated from the engineering stresses (σ) and engineering strains (ε). The engineering stresses and engineering strains are found out from tensile coupon tests. The specimens are prepared as per IS 1608 2005. The young's modulus of 2.01 x 105 N/mm2 and the yield stress of 345 N/mm2 and 450 N/mm2 is obtained from the coupon test.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

D. Coupon test results

The stress – strain relationship of tensile coupon was derived from load elongation relationship using its original cross-sectional area and the gauge length. The cross –sections area of flat coupon was determined by measuring theactual minimum width and thickness within gauge length to the nearest 0.02mm using vernier scale.

Figure 2Coupon Test Specimen

Figure 3 Coupon Test Result

E. Connection, loading and boundary conditions

The connection between the sections was modelled by using mesh independent fastener option. The two reference points were created at the middle of the contact surfaces between the load transferring plates and the specimen to simulate the two loading points. All the loads and boundary conditions were applied through the reference points RP1, RP2, RP3 and RP4. The loading and boundary conditions were applied to the node sets. The beam ends were modelled by restraining against all degrees of freedom except the in-plane rotation (UR4) at hinge end and releasing both the in-plane rotation (UR4) and axial translation (U3) along the beam length at the roller end. MPC Constrains are applied in order to achieve the torsional and warping resistance in reference points RP1, RP2.

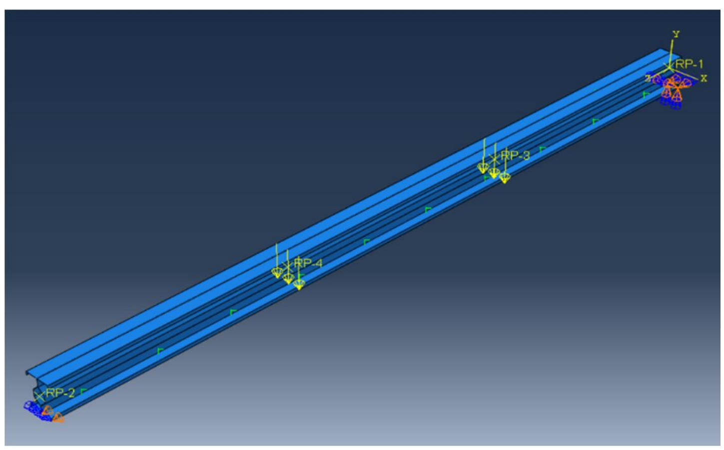


Figure 4 Abaqus Model

IV. EXPERIMENTAL INVESTIGATION

A. General

Experimental investigation in the context of the structural behavior of laterally restrained cold-formed steel sigma purlins refers to conducting physical tests and measurements on actual purlin specimens in a controlled environment. The main goal is to observe, analyze, and quantify how these purlins behave under various loading conditions and restraints.

B. Experimental Setup

The following figures gives the experimental Setup and the LVDT setup. 1 - LOAD CELL (100T), 2 - SPREADER BEAM, 3 - CFS SIGMA BEAM,4 – LVDT, 5 - HINGED SUPPORT, 6 - ROLLER SUPPORT

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

C. Four Point Loading System

Four-point loading is a mechanical testing technique used to determine the mechanical properties, particularly the bending behavior, of materials. It involves applying a specific load at four distinct points along a specimen to evaluate its flexural strength, stiffness, and deformation characteristics.

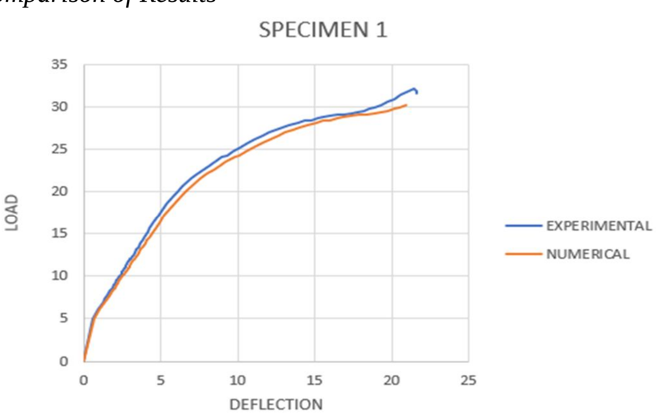
Figure 5 Experimental Setup

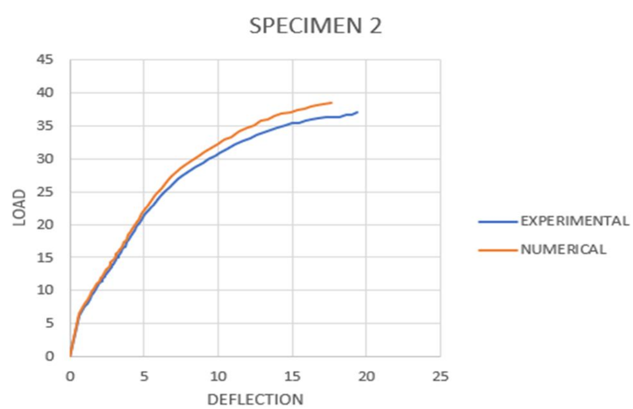
V. RESULT AND DISCUSSION

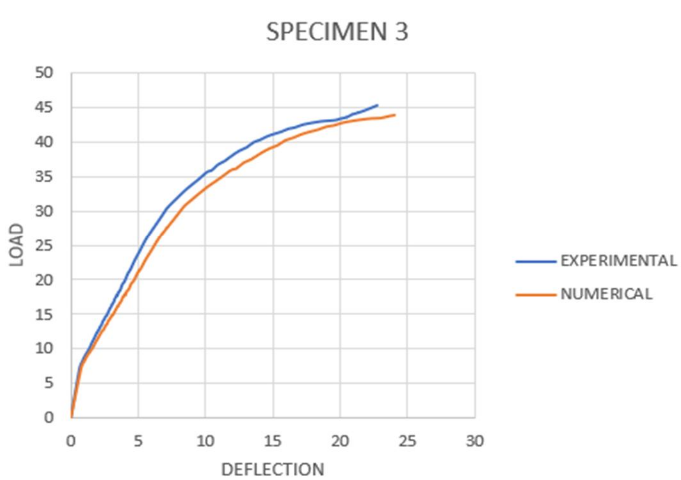
A. General

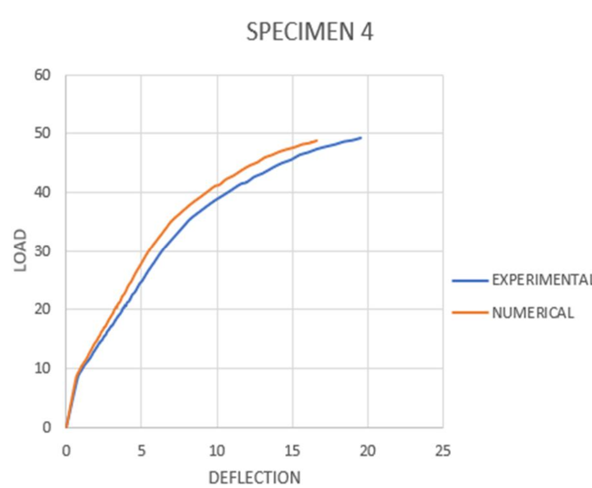
The process of comparing the outcomes derived from both numerical investigations and experimental studies has culminated in the emergence of a conclusive result. Through a meticulous analysis and rigorous examination of the data generated from these two distinct approaches, a comprehensive understanding has been achieved. This result not only affirms the validity and accuracy of the numerical simulations but also corroborates them with real-world experimental findings.

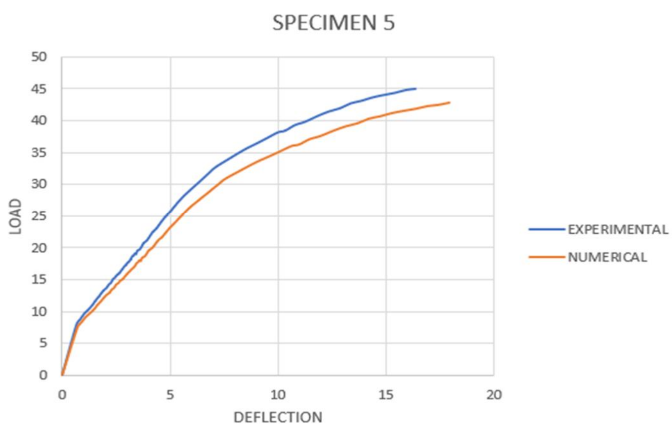
B. Comparison of Results

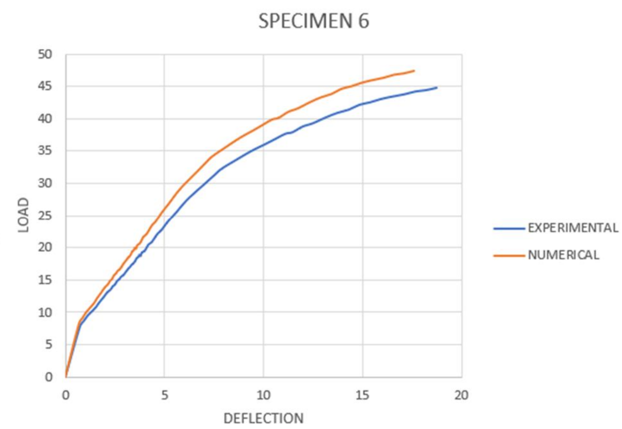












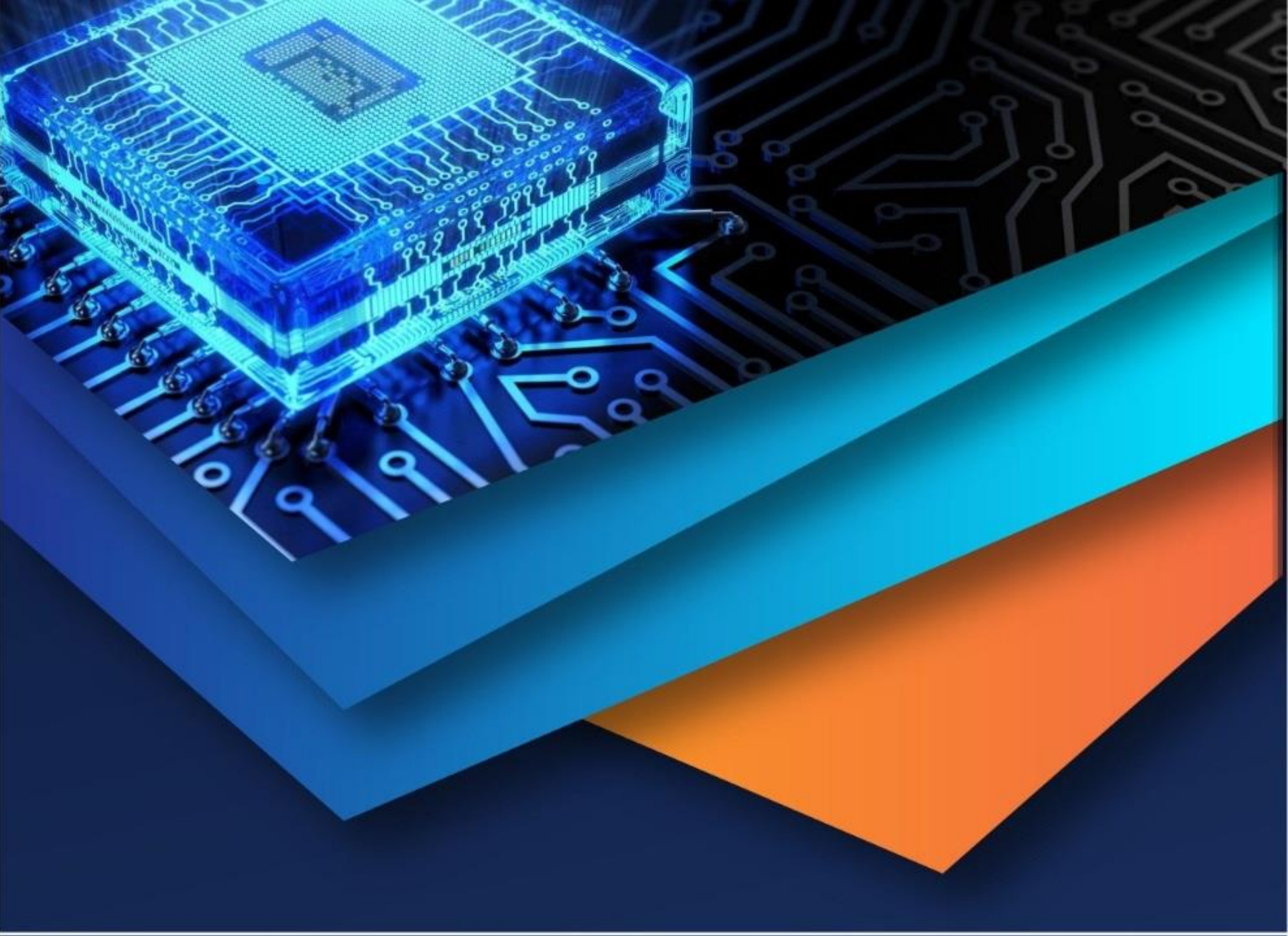
As compared with the Numerical Results, the results are same. Hence the results are validated. The specimen 3 & 4 has more load carrying capacity when compared with the other specimens, hence 200x100x1.6 mm and 200x100x2 mm are more compactable and optimum section to be used.

VI. CONCLUSION

The failure pattern observed is local buckling failure which occurs mostly under the load application. Hence its necessary to provide flange stiffeners at the required place. When the beam is laterally restrained the load carrying capacity also increases. These results when compared with unrestrained beams it increases by 12.8%, 18.6%, 24.26%. when the depth of the beam increases the load carrying also increases.

REFERENCES

[1] Amoke Shabhari, Dr.R. Thenmozhi(2021), "Numerical investigation on the behavior of cold formed steel sigma purlins."(EFCMS 21)
[2] M. Anbarasu (2019) "Simulation of flexural behaviour and design of cold-formed steel closed built-up beams composed of two sigma sections for local buckling" Engineering structures 191(542-562)
[3] R. Kandasamy, Dr.R. Thenmozhi, L. S. Jeyagopal, 2016, "Flexural-Torsional Buckling Tests of Cold-Formed Lipped Channel Beams Under Restrained Boundary Conditions", International Journal of Steel Structures, Vol. 16, Issue 3, pp. 765 – 776.
[4] V. Chandrikka, S. Shanmugavel, B. Sivasurya, B. Soundarya Lakshmi, M. Praveen kumar, "Analytical and Experimental Investigation of Cold Formed Steel Sections under Bending". International Journal of Scientific Engineering and Science Volume 3, Issue 4, pp. 5-10, 2019
[5] Eurocode 3, "Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting"
[6] BS 5950-5:1998, "Structural use of steelwork in building, Part 5: Code of practice for design of cold formed thin gauge sections".
[7] NAS, North American Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute, AISI S100-2007, AISI Standard.
[8] IS 801 – 1975 (R 2010) "Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members in General Building Construction".
[9] IS 811 – 1987, "Cold Formed Light Gauge Structural Steel Sections".
[10] Kavya.E, Swedha .T(2017), "a comparative study on experimental behaviour of cold formed sigma and z section purlin connections" International Journal of Scientific & Engineering Research Volume 8
[11] K.Subramaniyan, Dr.R.Thenmozhi, (2020), "numerical investigation on the flexural behaviour of cold formed steel sigma beam", IJCRT | Volume 8
[12] Qiang Liu, Dr Jian Yang, Dr. Long-yuan Li "Structural performance and design of cold formed steel Sigma sections"
[13] V. Raghul, N. Uma Maheswari, 2015, "Analytical Investigation on Cold-Formed Steel Built-Up Section Under Flexure", IJAERT, Vol. 3 Issue 4.
[14] Jian Yang, Qiang Liu, 2012, "An Experimental Study into Flexural Behaviour of Sigma Purlins Attached with Roof Sheets", Engineering Structures Vol. 45, pp. 481 – 495.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY