



MODELING, ANALYSIS AND OPTIMIZATION OF CURVED GALLERY FOR A PIPE CONVEYOR



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A Project Report



Submitted by

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*in partial fulfillment for the award of the degree
of*

**Master of Engineering
in
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**DEPARTMENT OF MECHANICAL ENGINEERING
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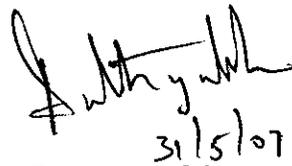
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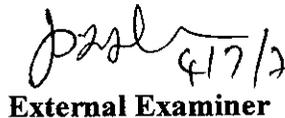


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To Whom It May Concern

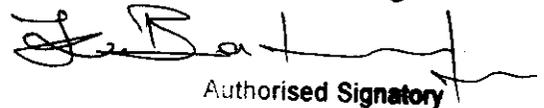
This is to certify that **Mr.M.R.Raveendran (71205402006)**, M.E. (CAD/CAM) of Kumaraguru College of Engineering and Technology has successfully completed the project work entitled **“Modelling, Analysis and Optimization of Curved Gallery for a Pipe Conveyor”** in **“Fivelement Tekhnologies”** during the month of February 2007 to March 2007. This Project work was carried out under the guidance of **Mr.M.Balachandar.**

Fivelement Tekhnologies,



M. Balachandar.

For FivElement Tekhnologies



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National Conference on Extreme Engineering and Technological Advancements

XETA - 2K7

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This is to certify that Mr/Ms M.R. RAVEENDRAN presented paper on

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in the National Level Conference on Extreme Engineering and Technological Advancements XETA - 2K7 held at Jayam College of Engineering Technology, Dharmapuri, Tamil Nadu during 4th & 5th, April - 2007.

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ABSTRACT

Pipe Conveyors are used for transfer of materials from one place to another without spillage of materials. Pipe conveyer is less loss of material while conveying and also it can be bent in any direction giving flexibility in conveying bulk material. In this design the total length is supported by 3 to 6 supports. Every support is roughly 10 to 120m heights. Here the space frame support is turning with a radius of 70m for 90 degrees and the total curved length turns out to be 709m, at the same time there is an increase in elevation from 1.1m to 121.1m. Decrease in the total number of supports will decrease the support cost out of the sections to be used in the space. The objective of this project is to design space frames for supporting conveyor structure, when it is turning in all directions, also to reduce the total cost and optimize the design of space frame and the support.

ANSYS software is used for structural analysis of the curve modeled using Pro-E software.

KEYWORDS: Curved Gallery, Support, Pitch and Stress.

ஆய்வுச்சுருக்கம்

பைப் கன்வேயர் ஆனது பொருட்களை ஓரிடத்தில் இருந்து மற்றோர் இடத்திற்கு சிதறாமல் கொண்டு செல்ல பயன்படுகிறது. பைப் கன்வேயர் குறைந்த பொருட்சேதம் மற்றும் நெகிழ்வுத் தன்மையுடன் கொண்டு செல்ல கூடியது. இந்த அமைப்பின் நீளத்தை 3 முதல் 6 ஆதாரங்களை கொண்டது. ஒவ்வொரு ஆதாரமும் ஏறத்தாழ 10 முதல் 120 மீட்டர் உயரமுள்ளது. இந்த முழுஉருவ சட்டக்கட்டிலானது வளைவு ஆரம் 70 மீட்டர், 90 டிகிரிக்கு மற்றும் மொத்த வளைவு 709 மீட்டர் நீளமானது. அதே சமயத்தில் எழுச்சி 1.1 மீட்டரிலிருந்து 121.1 மீட்டர் வரை அதிகமாகக் கூடியது. ஆதாரங்களின் எண்ணிக்கையை குறைக்கும் பொழுது ஆதாரச் செலவும் குறைகிறது. இந்த ஆய்வின் இலக்கானது முழு உருவ சட்டக்கட்டிலை அனைத்து திசைகளிலும் வளைத்தலுக்கு ஏற்றவாறு அமைப்பதாகும், மற்றும் மொத்த செலவையும் சட்டக்கட்டிலை அமைப்பதற்கான செலவையும் ஆதாரங்களை ஆப்டிமைஸ் செய்வதாகும்.

புரோ- இ என்ற மென்பொருளைக் கொண்டு வடிவமைக்கப்பட்ட வளைவை, ஏன்சிஸ் என்ற மென்பொருளை உபயோகித்து அமைப்பியல் ஆய்வு செய்யப்பட்டது.

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LIST OF SYMBOLS & ABBREVIATIONS

P_c	=	Buckling load
N	=	Coefficient of end condition
E	=	Young's Modulus
I	=	Area of Moment of Inertia
L	=	Length of Column
W	=	Total Weight
P_1	=	Pitch in Degree
P_2, P_3, P_4	=	Diameter of the pipe
A, B, C, D, E	=	Constants

Chapter 1

Introduction

Chapter 1 Introduction

1.1. Material handling systems

Need of the present day is for the equipments to handle heavy loads with fast speed, reliability, safety and economy. In order to meet the variety of requirements, equipments of different types and sizes have been developed and manufactured. Application of material handling devices is a prime consideration in designing new plants and for modifying existing plants. These devices increase output, improve quality, speed up the deliveries and therefore, decrease the cost of production. Utility of these devices have further been increased due to increase in labour costs and problems related to labour management.

1.2. Conveyors

Nowadays, the diversity of the various processes of mining, transportation, loading and unloading, and storage continually increases the requirements of the conveying technology. The continuous efforts of the facility designers, to make transport procedures more economical through organized operating guidelines, opened up new fields of operation with higher requirements and a stronger specialization to the conveying technology.

The bulk material conveying technology, a powerful and highly specialized field of the conveying technology, is characterized by its distinctive technical variety. The development of conveyors for bulk materials concentrates on reaching higher operational reliability, economic efficiency besides meeting environmental requirements.

1.3. TYPES OF CONVEYORS

A. TRACTION TYPE CONVEYORS

- Belt conveyor
- Chain conveyor
- Cage elevators
- Roller conveyor
- Bucket elevators

B. TRACTIONLESS-TYPE CONVEYORS

- Gravity-type conveyors
- Chutes screw or spiral conveyors
- Conveying by hydraulic means
- Pneumatic conveyors
- Vibrating and oscillating conveyors

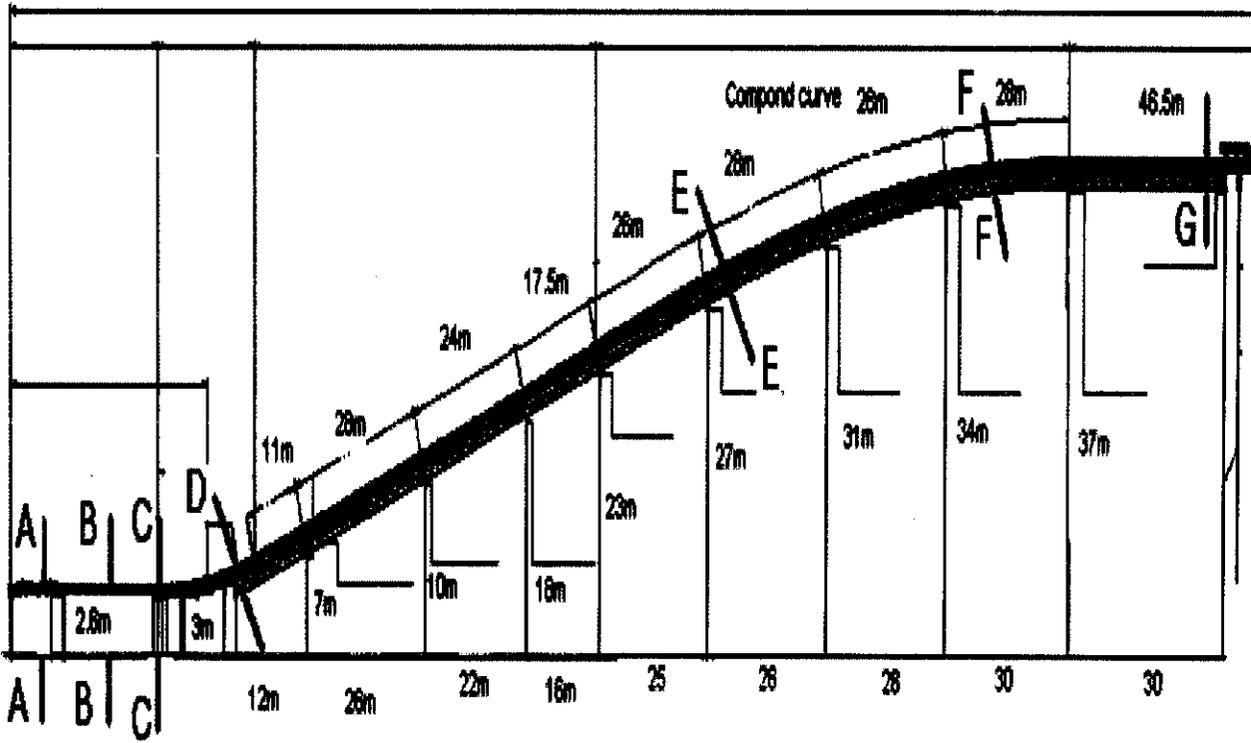
1.4. Belt conveyor

Belt conveyors are the most common form of materials handling system used in manufacturing and mining industry, thermal plants and in construction projects. Belt conveyors consists of a belt running over drums or pulleys provided at the end and are supported at intervals by a series of rollers known as idlers. These idlers are supported on the conveyor frame. These idlers help to support the conveyors and reduce the sag of the belt and prevent the loose materials from spilling. These idlers are free to move on bearings. Since 1000 to 1200 idlers per kilometer belt length are provided, it is important to design, select and maintain for maximum life and to give best performance. The spacing of idlers depends upon the weight of the material handled. If the idlers are widely spaced, the sag between them becomes excessive, which will result in wastage of power, increase in belt wear, chances for spillage of material due to impact at each idlers.

1.5. Gallery

Support trusses, galleries and bents are similar to those used with conventional conveyors. Idler alignment and proper belt loading play a key role in the stability and tracking of the pipe conveyor. On a conventional conveyor structure the idler support steel, horizontal and vertical alignments are critical for proper belt training a successful operation. With the pipe conveyor belt guided by idlers surrounding the belt on all sides, the conveyor is able to negotiate curves and centerline misalignments. During commissioning of the pipe conveyor, idler alignment to the belt is adjusted to maintain the belt overlap in a position that is located as near the top as possible on the carrying side. However, what actually assists most in belt stability and keeps the overlap at or near the upward position is the weight of the material conveyed. The center of gravity on the lower 75% cross section maintains the proper dynamic attitude of the conveyor belt. On the return or empty side, the belt overlap is located at the bottom of the pipe shape. The extra weight of the overlap maintains the proper dynamic attitude on the return run. Uniform feed to the pipe conveyor is important to its stability and tracking. For this reason it is recommended that feeders be used and, to assure a constant and uniform flow of material in the pipe conveyor, a monitor and variable speed drive be employed. The cross-section monitor detects the material load at the loading chute and provides a signal to vary the belt speed to facilitate the uniform cross-section at all times.

Plan View of Gallery



1.6. Triangular gantry structure

This structure takes its lead from the extensive developments of large span architecturally pleasing structures such as roof structures. The triangular gantry with its low cost, bringing it in line both environmentally and on corrosion terms requires serious consideration. Using the high strength of pipe structure this is approaching the optimum design of low cost high span and lift solutions.

Like its own development however, it requires a re-look at the way conveyors have been built in the past and specifically support structures for the idlers and the way the mechanical components are maintained on the conveyor structure.

Chapter 2

Literature Review

CHAPTER 2 LITERATURE REVIEW

2.1 Literature review

Nordell et al. (1998) presents an introduction to the modern analysis techniques used in determining the magnitude of the dynamic transient forces propagated in a conveyor belt during its starting and stopping phases. Transient forces can be generated which impair the integrity of the conveyor system. Prediction, control, and allowance for these forces is essential for a successful design. Prediction of the transient behaviors has been accomplished with the aid of a computer modelling tool tradenamed BELTFLEX. The program simulates the rheological effect of longitudinal vibration in the belt resulting from changes in the equilibrium forces. Practical applications and case studies are noted. A method of modelling the true elasto-mechanical dynamic behavior of the belt has been introduced, together with a brief discussion on two case studies. A number of studies have been completed which provide insight into the many aspects of conveyor design, insight which is only discernible through elastic-transient modelling. The BELTFLEX model, used for these studies, utilizes a non-linear finite element approach. It is based on the discrete time-integration method of solving the second order differential equation of wave mechanics in viscoelastic solids.

Lawrence (1998) presented in determining: a) conveyor belt frictional rolling resistance, b) belt strength criteria and its relation to belt splice dynamic efficiency, c) belt cover life determination associated with transfer station design (rockbox and curved chute), and d) issues of noise generation. Significant improvements in performance and cost can be realized by properly quantifying the cover and core rubber properties, and in mitigating belt damage at the transfer station. Belt suppliers can produce cover rubber compounds with superior rolling resistance properties. Engineering tools can now rank the performance of these new rubber products against their cost and derive significant benefit in overall capital and operating charges. Splice fatigue strength and efficiency is shown to reach far beyond the industrial standards. Belts have been tested up to ST-8 800 N/mm and

methods of analysis make it possible to reliably reduce the steel cord belt safety factor from 6.7 down to 4.5. Dynamics and controls were briefly reviewed demonstrating that belt elastic stretch can cause control perturbation. The total expected life cycle must be considered in the safety factor calculations. Belt wear has been successfully controlled by utilizing curved chute technology. Curved chute design is aided by a new ore flow modeling technique called Discrete Element method (DEM). DEM models the particle physics similar to the action of rocks in a flow stream. Collision damage can be quantified for all surfaces. Belt wear classification into measurable abrasion indices is now possible. Case studies demonstrate the accuracy of the viscoelastic theory. ZISCO's 15.6 km successful lame pitch idler spacing (5 m carry side and 1cm return side) is noted. Noise engineering and standards need to be introduced into conveyor engineering criteria. Present measurement methods may require revision.

Lodewijks (1997) Beam elements can be applied in finite element models of long belt conveyor systems in order to simulate the belts global elastic response, in both longitudinal and transverse directions, during starting and stopping. The advantage of applying beam elements instead of truss elements is that the coupling between the longitudinal and transverse response of the belt can be taken into account. Comparing the discretisation of a belt conveyor to a finite element model built of truss and of beam elements shows that especially the way the boundary conditions are treated is different. If a mixed model, built of both truss and beam elements, is applied then the simulations will be accurate and not too time consuming. The application of beam elements in a finite element model of a long belt conveyor system will result in a more realistic prediction of the response of the belt during starting and stopping. However, if only beam elements are used then the number of independent displacement and strain components, the degrees of freedom, will be very large. This results in time-consuming and expensive calculations. It is also not necessary to use exclusively beam elements. Truss and beam elements can be combined in one model which will result in less time consuming calculations. The beam elements can, for example, be used in the drive and take-up section and in convex and concave curves. They can also be used in monitoring sections where the transverse displacement of the belt is monitored in order to detect standing

by beam elements. The application of a combined finite element model in simulation programs will enlarge the insight in the wave phenomena which occur in the belt during starting and stopping. This will help the development of components of new long conveyor systems.

N.P.Chowdhuri,(1994)‘Conveyor belt for transportation of bulk material, comprising a central part and two integrated side parts which side parts are in an unbiased, free-state form angled in relation to the central part to obtain a substantial inherent stiffness, and to achieve self aligning of the belt; a lower portion of the central part comprises a longitudinal and transversal reinforcement and that an upper portion thereof comprises resisting material and said side parts are covered with wear resistant material and longitudinal and transversal reinforcements in their bulk material carrying part; the transversal reinforcement covers the side part and extends partly into the central part in order to increase the resistance to transversal bending; the transversal reinforcement maintains the side parts in an angled state throughout all operations of the conveyor belt; and the side parts having equal height and the thickness of the central part being equal to or thicker than the thickness of the side parts.

C.Selmer, M.P.Paidoussiss (1995) Conveyor belt for bulk material handling. The conveyor belt consists of a central part and two integrated side parts which side parts are from the beginning manufactured angled in relation to the integrated central part in order to give the conveyor belt an increased resistance to bending. The central part is preformed to contain longitudinal and transversal reinforcement in its lower part in order to increase the thickness of the wear resisting material in the upper part. The side parts are provided with wearing resisting material and longitudinal and transversal reinforcement. The side parts are angled at an angle α in relation to the central part, which angle in a preferred embodiment is approximately 45.degree or 90 degree. The conveyor belt is carried by cables or a number of rollers.



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C.Y.Wang, (2003) This paper presents an argument in favor of the social nature of

and knowledge base. The scope narrows down to the field of architecture. The conceptualization proposed will facilitate the reinterpretation of architectural design, educational practices, customary responsibilities of designers and client expectations. The area of concern is related to several domains of design studies: the philosophy of design, the nature of design activity, the design object, design education and curriculum, the scope of design knowledge and skills and the definition of the design profession regarding responsibilities and competencies. The range of these issues as well as the current interest in the social impact of design make the topic of this article an important one to be developed within the field of design. In this paper we have adopted a theoretical approach. Based on the analysis of the object and process of design we develop an argument for the social nature of architectural design. The paper is organized in three sections. The first of these develops the ontological basis for the ensuing argument. It presents a model of the design object that explicates the social underpinnings of the complex relationships that comprise the architectural artifact. This conceptualization creates a reference basis for the ensuing argument. The second section models the structure of the design process in terms of informed decision-making. The third section discusses the implications of the ontological interpretations for construing the architectural process as social design.

Due to the great number of idlers required for creating the pipe in conventional belt conveyors (12 idlers per idler station), the sum of the kinetic resistances increases along the transport route and results in a large amount of power needed for the drive motor(s). Furthermore, the large number of idlers causes excessive noise, which can exceed the permissible limits - especially in the neighborhood of villages or cities - and, often necessitates acoustically absorbing housing of the entire conveying path. Starting with the initial intention of reducing the number of idlers as well as the noise along the travel path, a new kind of belt guidance was developed at the Department for Conveying Technology and Design Methods, Mining University of Leoben, and subsequently patented (Austrian patent registration No. 1126/99) [1, 2]. Hereby the returning belt is not - as usual - executed as closed belt but is turned round by additional idlers on both ends of the travel path, so that the return strand rests on the already existing idlers of the

pipe-conveyors; the two upper idlers on each side are longer to support the belt over its entire width. The finger idlers, which are situated in certain distances near the extended upper idlers, are necessary to guarantee a steady belt run in curves. They support the belt and prevent it from slipping off. To allow this new kind of system to operate properly, the return stations had to be completely redesigned. Especially the assembly of the deflection idlers and the design of the charging and discharging station had to be changed. The suitable constructive measures for this new type of pipe conveyor at the return stations are displayed.

Day for day, Pipe Conveyors all over the world prove their reliability in transporting the most diverse bulk materials, including critical materials such as wet and fly ash, coal and substitute fuels from recycled industrial wastes, wood chips and raw material pellets, filtered slurries and biomass, coarse overburden and finest powders such as gypsum or cement. Pipe Conveyor systems can be designed for every conceivable application from small, compact units for conveyance within a plant through kilometer-long systems for overland conveying. The design can be individually adapted to the client's requirements, adjusted carefully in every detail to the environmental parameters as well as the characteristics of the conveyed material.

2.2 Problem definition

Conveying material through belt conveyor could become disadvantageous especially for the reason that:

- Conveying through open air, the environment could react the material changing property of the material.
- Spillage could take place during long conveying.
- Belt Conveyor cannot be easily turned. They always take straight path.
- Inclination of Belt Conveyor is limited due to the angle of response problem.

All these problems are overcome by use of a Pipe Conveyor. A Pipe Conveyor is a

problem, which is going to be handled in this project, is the design of the supporting Gallery for the Pipe Conveyor. Since the lengths of these conveyors are in Kilometers, the supporting structure from the ground should be as low as possible. Any saving in weight per meter could lead to a huge saving in a Kilometer stage. The particular case considered in this project is the turning of Gallery with a radius approximately 70 meter. The task is not only to design a gallery which is not only turning but the elevation of the starting & ending point are also different. The scope could be to first develop a layout design for the Gallery & supporting structural. A shorter span of supporting structural could lead to a reduced section of Gallery numbers, but the cost of supporting structure would go up due to increase in number of supporting structures. Similarly an increase in span will reduce the total number of supporting structures but could lead to heavy sections of Gallery which leads to increased cost of Gallery numbers. Our objective will be to determine the apt number of structures and section of Gallery numbers, which will lead to are overall minimum, weight or cost. A change in the pitch of triangular supports could also be varied to find out the optimal pitch for a given Gallery support span. The current span of supporting numbers is approximately 27 meters and the number of triangular middle sections for the span is 11. The total developed length of each span is 28 meters & the total developed length of compound curve (radius of bend angle of 90 degree) is approximately 110 meters. For modeling the compound curve, the Pro/E Software and for structural analysis, ANSYS Software were used and later the optimization technique will be adopted to achieve optimal configuration.

Chapter 3

*Modelling &
Analysis of
curved
gallery*

CHAPTER 3 MODELLING AND ANALYSIS OF CURVED GALLERY

3.1 Introduction

The conveyor belt is usually increased with one size to allow for the side drift between empty and loaded conditions. Temperature change and weather conditions are also critical factors in sizing curve radii with the conventional belt of the two, eliminating transfers or passing around, over or under existing plant equipment. The curved sections are begun only after the belt passes through the transition section and is in the pipe shape. The curved sections must be completed while still in the pipe shape prior to exiting through the transition section to the discharge pulley. The transition sections must be straight at both ends.

The radius of the curves is generally a function of the pipe conveyor diameter, the type of belt and curve used. In general the standard minimum recommended radius for the horizontal or concave curves for a fabric belt is 300 times the pipe conveyor diameter and is 700 times the diameter, for a steel cord belt. In case of a combined horizontal and convex curve the minimum radius is then 800 times the diameter for steel cord belt. In all cases the final selection of radii is based on our engineer's complete review of the static and dynamic tension conditions of the individual pipe conveyor and the type or combination curves that are used.

3.2 MODELLING

For modeling the compound curve PRO-E software was used.

3.2.1 Curved gallery

The radius of the curves is generally a function of the pipe conveyor diameter, the type of belt and curve used. In general the standard minimum recommended radius for the horizontal or concave curves for a fabric belt is 300 times the pipe conveyor diameter and is 700 times the diameter, for a steel cord belt. In case of a combined horizontal and convex curve the minimum radius is then 800 times the diameter for steel cord belt. In all cases the final selection of radii is based on our engineer's complete review of the static and dynamic tension conditions of the individual pipe conveyor and the type or combination curves that are used.

SCHEMATIC REPRESENTATION OF CURVED GALLERY



3.3 METHODOLOGY

The particular ease considered in this project is the turning of Gallery with a radius of starting and ending points are also different. The scope could be to first develop a layout design for the gallery and supporting structural. A shorter span of supporting structure could lead to a reduced section of gallery numbers. But the cost of supporting structural would go up due to the increase in number of supporting structures. Similarly an increase in span will reduce the number of structures but will lead to heavy sections of gallery, which would increase gallery cost. Our objective will be to determine the apt number of structures and section of gallery numbers, which will lead to are all overall minimum weight or cost. A change in the pitch of triangular supports could also be varied to find out the optimal pitch for a given gallery support span. The current span of supporting numbers is approximately 27 meters and the total developed length of compound curve (radius of bend angle 90 degree) is approximately 110 meters. For modeling the compound we will be using Pro/E software and for structural analysis we will be using ANSYS Software and later the optimization technique will be adopted to achieve optimal configuration. Using GEM (Gauss Elimination Method) to find out the optimal solution.

3.4 Analysis

For analysis the compound curve ANSYS software was used.

Introduction about ANSYS:

ANSYS is a complete FEA simulation package developed by ANSYS- INC- USA. ANSYS is a general purpose finite element analysis solving a wide variety of mechanical problems. These problems include static/dynamic in structural analysis (both linear and non-linear), heat transfer and fluid problems, as well as acoustic and electro – magnetic problems.

Solution stages

In general, a finite element solution can be broken into the following three stages. This general guideline can be used for setting up any finite element analysis.

A.Preprocessing: defining the problem

The major steps in preprocessing are given below:

- Define key points/lines/areas/volumes
- Define element type and material/geometric properties
- Mesh lines/areas/volumes as required

-The amount of detail required will depend on the dimensionality of analysis (i.e. 1d, 2d, axisymmetric and 3d)

B.solution stage

Assigning loads (point or pressure), constraints (translational and rotational) and finally solve the resulting set of equation.

C.Post processing: further processing and viewing of the results

In this stage, one may wish to see:

- Lists of nodal displacements
- Element forces and moments
- Deflection plots
- Stress contour diagrams

Applications

Engineers use it worldwide in virtually all fields of engineering:

- Structural
- Thermal
- Fluid (CFD, Acoustics, and other fluid analysis)
- Low and High Frequency electromagnetic-A partial list of industries in which ANSYS is used:
- Aerospace
- Automotive
- Biomedical
- Bridges

Electronics and appliances

-MEMS-Micro Electomechanical Systems

-Sporting Goods.

Capabilities

In ANSYS, the following analyses can be performed.

Structural Analysis

Structural analysis is used to determine deformations, strains, and stresses and reaction forces.

Structural analysis are classified as follows

-Static analysis

-Dynamic analysis

-Modal analysis

-Harmonic analysis

-Transient Dynamic analysis

-Other structural capabilities

-Spectrum analysis

-Random vibrations

-Eigenvalue buckling

-Substructuring, submodeling

Thermal analysis

Thermal analysis is used to determine the temperature distribution in object.

Two types of Thermal Analysis are,

-Steady state

-Transient

Electromagnetic analysis

Electromagnetic analysis is used to calculate magnetic fields in electromagnetic devices. Types of electromagnetic analysis:

-Static analysis-Harmonic analysis

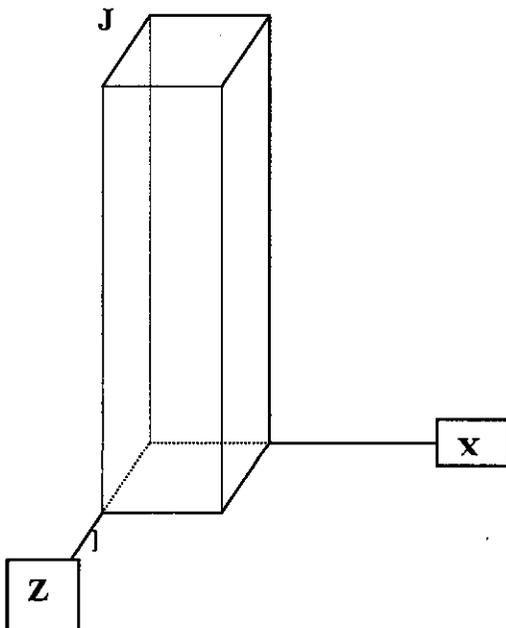
-Transient analysis

Computational Fluid Dynamics (CFD)

Used to determine the flow distribution and temperature in a fluid.

BEAM4- Element description

BEAM4 is a uniaxial element with tension, compression, torsion, and bending capabilities. The element has six degrees of freedom at each node: translations in the nodal x , y , and z directions and rotations about the nodal x , y , and z axes. Stress stiffening and large deflection capabilities are included. A consistent tangent stiffness matrix option is available for use in large deflection (finite rotation) analyses. Two or three nodes, the cross-sectional area, two area moments of inertia (I_{ZZ} and I_{YY}), two thicknesses (TKY and TKZ), an angle of orientation (?) about the element x -axis, the torsional moment of inertia (I_{XX}), and the material properties define the element. If I_{XX} is not specified or is equal to 0.0, it is assumed equal to the polar moment of inertia ($I_{YY} + I_{ZZ}$). I_{XX} should be positive and is usually less than the polar moment of inertia. The element torsional stiffness decreases with decreasing values of I_{XX} . An added mass per unit length may be input with the $ADDMAS$ value.



BEAM4- Input summary

Nodes

I, J, K (K orientation node is optional)

Degrees of Freedom

UX, UY, UZ, ROTX, ROTY, ROTZ

Real Constants

AREA, IZZ, IYY, TKZ, TKY, THETA

ISTRN, LXX, SHEARZ, SHEARY, SPIN, ADDMAS

See Table 3.4.1: "BEAM4 Real Constants" for a description of the real constants.

Material Properties

EX, ALPX (or CTEX *or* THSX), DENS, GXY, DAMP

Surface Loads

Pressures --

Face 1 (I-J) (-Z normal direction)

Face 2 (I-J) (-Y normal direction)

Face 3 (I-J) (+X tangential direction)

Face 4 (I) (+X axial direction)

Face 5 (J) (-X axial direction)

(use negative value for opposite loading)

Body Loads

Temperatures

T1, T2, T3, T4, T5, T6, T7, T8

Special Features

Stress stiffening

Large deflection

Birth and death

Table 3.4.1 BEAM4 Real Constants

No.	Name	Description
1	AREA	Cross-sectional area
2	IZZ	Area moment of inertia
3	IYY	Area moment of inertia
4	TKZ	Thickness along Z axis
5	TKY	Thickness along Y axis
6	THETA	Orientation about X axis
7	ISTRN	Initial strain
8	IXX	Torsional moment of inertia
9	SHEARZ	Shear deflection constant Z [1]
10	SHEARY	Shear deflection constant Y [2]
11	SPIN	Rotational frequency (required if KEYOPT(7) = 1)
12	ADDMAS	Added mass/unit length

1. SHEARZ goes with IZZ: if SHEARZ = 0, there is no shear deflection in the

2. SHEARY goes with IYY; if SHEARY = 0, there is no shear deflection in the element Z direction.

BEAM4- output description

The solution output associated with the element is in two forms:

- Nodal displacements included in the overall nodal solution
- Additional element output as shown in several items are illustrated in the maximum stress is computed as the direct stress plus the absolute values of both bending stresses. The minimum stress is the direct stress minus the absolute value of both bending stresses. A general description of solution output is given in See

3.6 COLUMN DESIGN

Total Column Weight = Total length * weight

Total Weight = Total column weight + Load

S. No	SECTOR	GALLERY WEIGHT (kgf)	SUPPORT WEIGHT (kgf)	TOTAL WEIGHT (kgf)
1.	Five	8335	2175.68	10510368
2.	Four	7408	1631.68	9039.68
3.	Three	13833	1087.68	14920.68

FIVE SECTORS

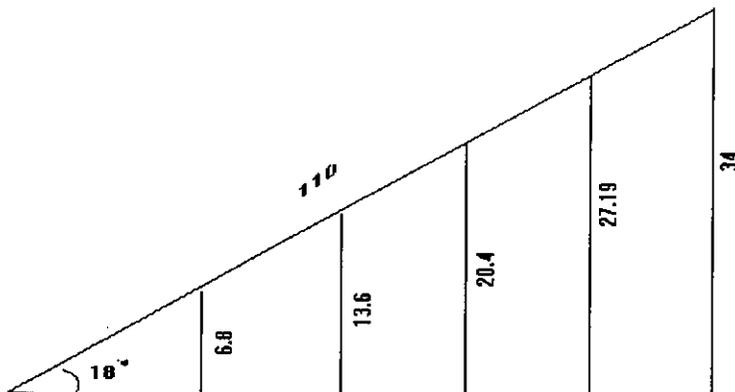
TotalLength=67.99m

Weight=32Kg/m

Totalcolumnweight=2175.68Kg

GalleryWeight=8335Kg

Total weight =10510.65Kg



FOUR SECTORS

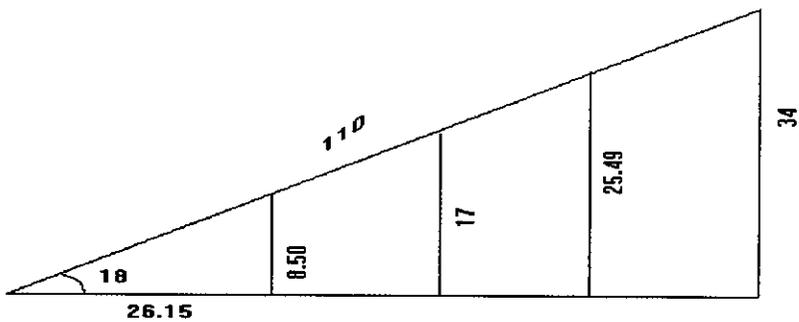
TotalLength=50.99m

Weight=32Kg/m

Totalcolumnweight=1631.68Kg

GalleryWeight=7408Kg

Total weight =9039.68Kg



ALL DIMENSIONS ARE IN mm

THREE SECTORS

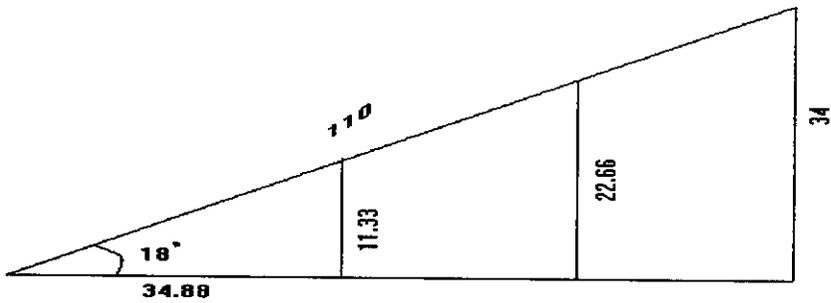
TotalLength=33.99m

Weight=32Kg/m

Totalcolumnweight=1087.68Kg

GalleryWeight=13833Kg

Total weight =14920.68Kg



ALL DIMENSIONS ARE IN mm

Chapter 4

Optimization

CHAPTER 4 OPTIMIZATION

4.1. Optimal Pitch

Table 4.1.1 Comparison with pitch for five sectors

S.No.	Pitch (Degree)	Weight (kgf)	Deflection (mm)
1.	1	2335	14.01
2.	1.2	1876	15.296
3.	1.5	1667	15.569
4.	1.8	1774	16.747
5.	2	1841	16.89

Polynomial Function:

The total weight is a polynomial function which is given by the formulae,

$$W=AP_1+BP_2+CP_3+DP_4+EP_1^2$$

Where,

W – Total Weight

P₁ – Pitch in Degree

P₂, P₃, P₄ – Diameter of the pipe

A, B, C, D, E - Constants

The Optimal Pitch = 1.3

Table 4.1.2 Comparison with pitch for four sectors

S.No.	Pitch (Degree)	Weight (kgf)	Deflection (mm)
1.	0.9	2951.3	14.01
2.	1.25	2258.91	15.296
3.	1.5	2051.07	15.569
4.	1.875	1851.51	16.747
5.	2.25	1862.5	16.89

The above table shows the comparison of pitch for four sectors and concluded that the optimal pitch is 1.86

Table 4.1.3 Comparison with pitch for three sectors

S.No.	Pitch (Degree)	Weight (kgf)	Deflection (mm)
1.	1	5966	14.92
2.	1.2	4833.5	15.296
3.	1.5	3368.65	15.569
4.	1.875	4611.36	16.747
5.	2	4985.4	16.89

The above table shows the comparison of pitch for three sectors and concluded that the optimal pitch is 1.95

Table 4.1.4 SECTORS COMPARISON

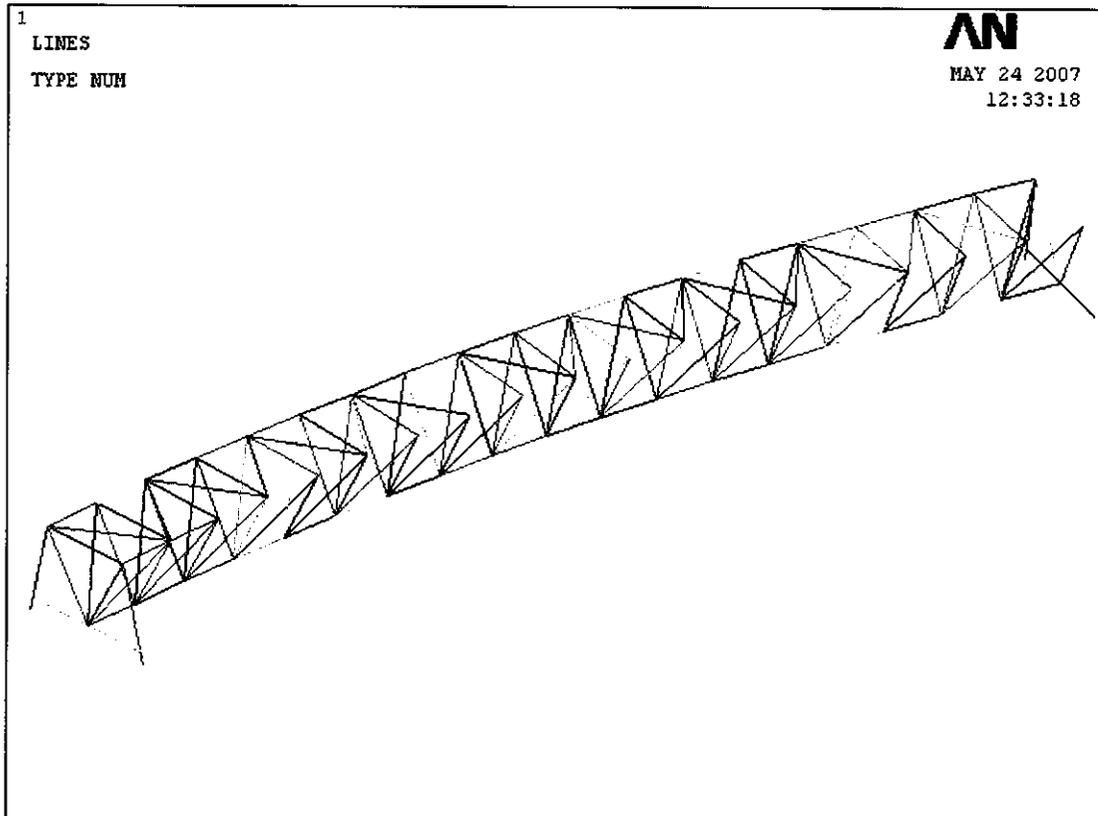
SECTOR	OPTIMAL PITCH
Five Sector	1.3
Four Sector	1.86
Three Sector	1.95

The above table shows that comparison between the three sectors and optimal pitch

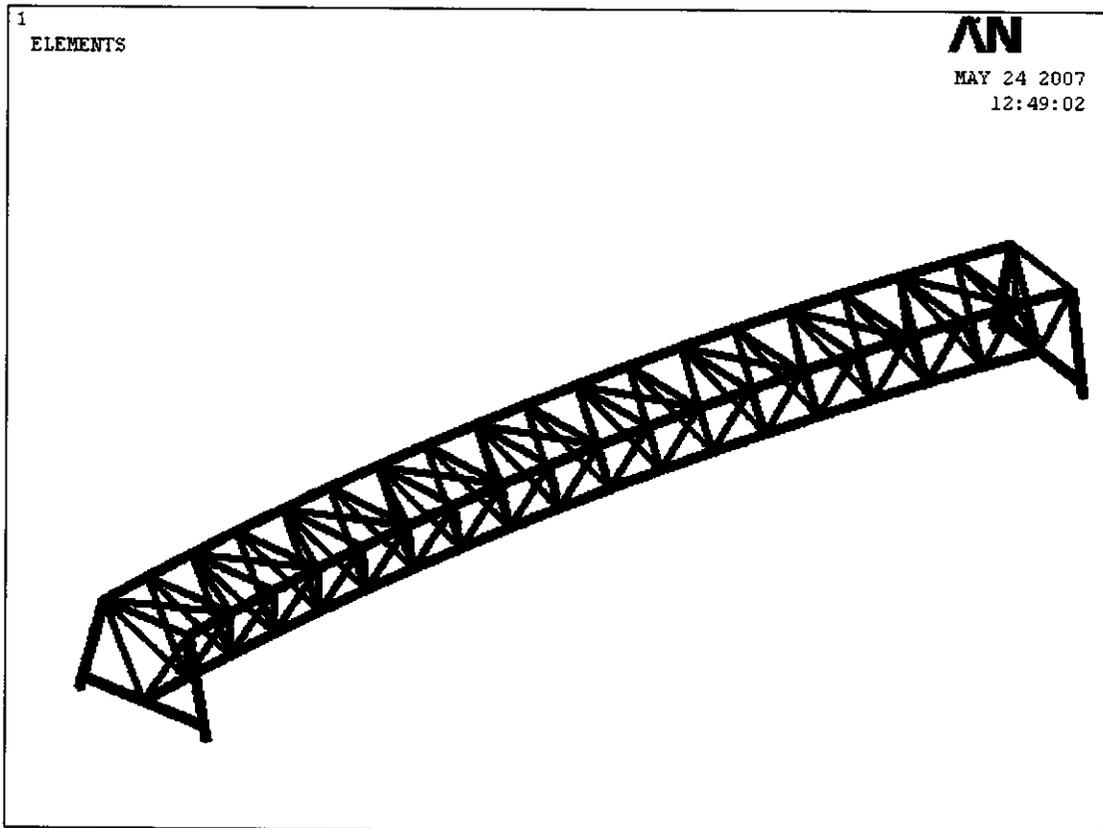
CHAPTER 5 RESULTS AND DISCUSSIONS

- Triangular Gantry brings the low cost and high strength compare to square gantry.
- Pitch is 2nd degree polynomial function of weight.
- Pitch is directly proportional to the deflection.
- Sector four proves to be the best design with reduced weight.
Gallery configuration for optimum pitch.

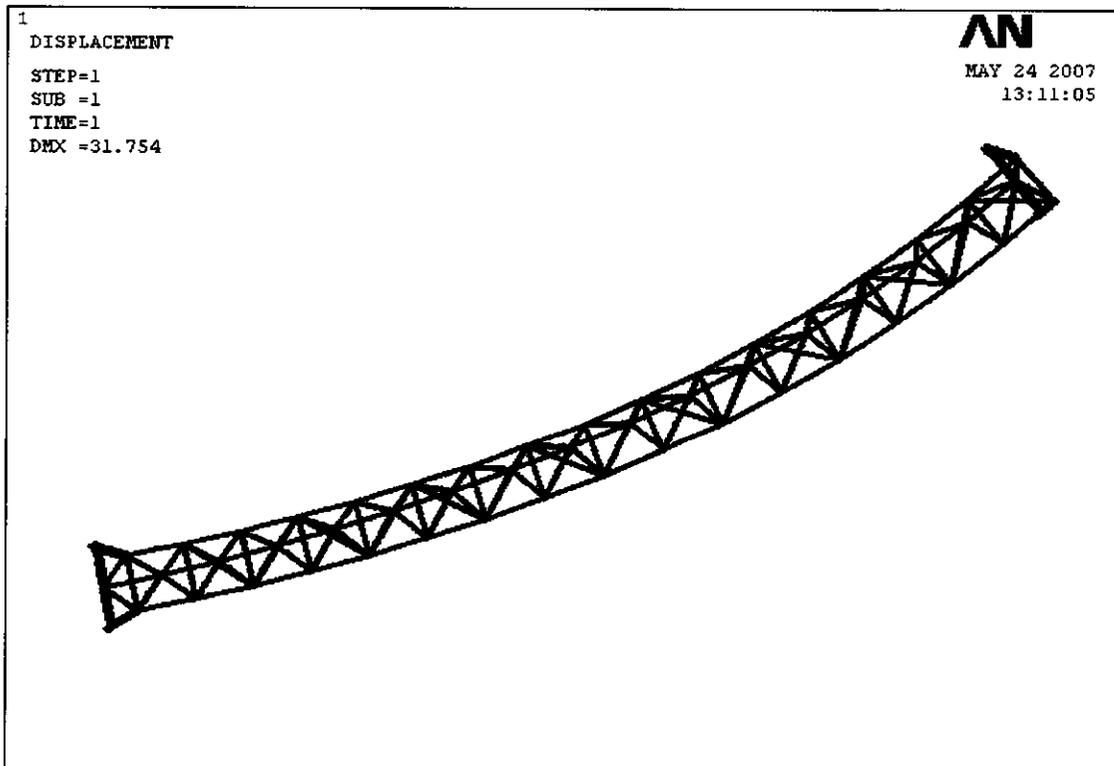
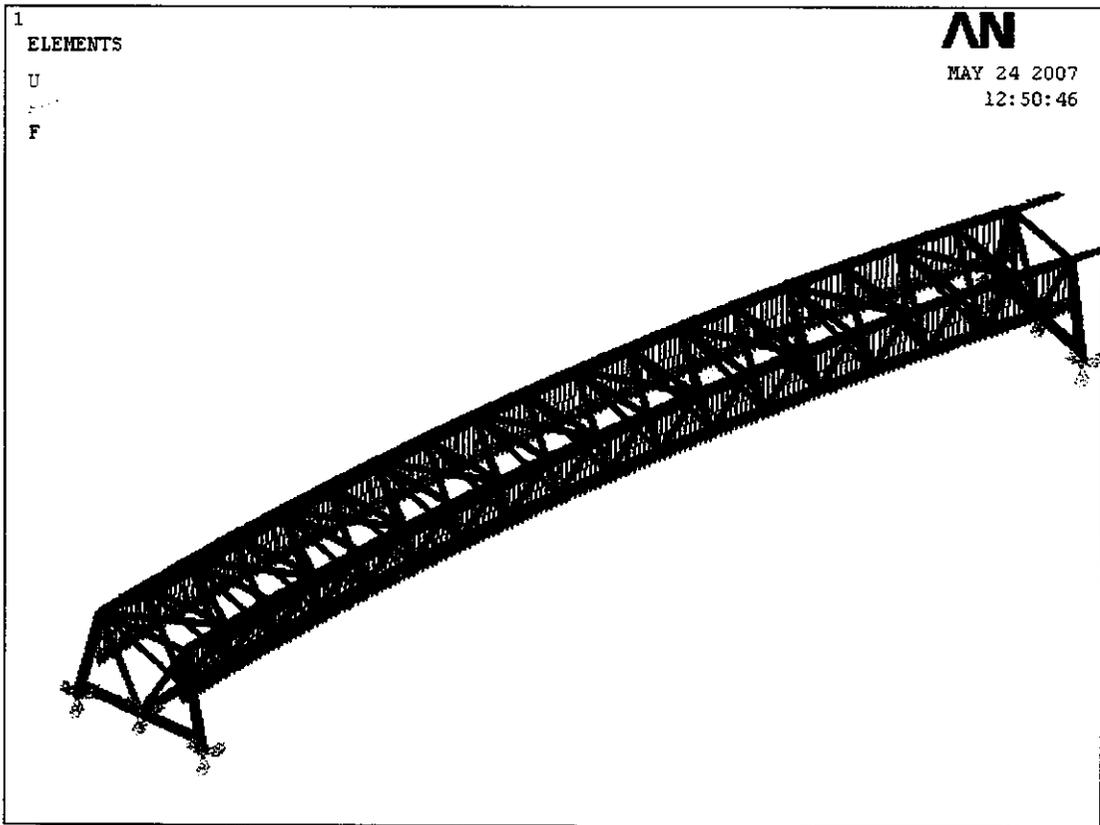
Model



Meshed model



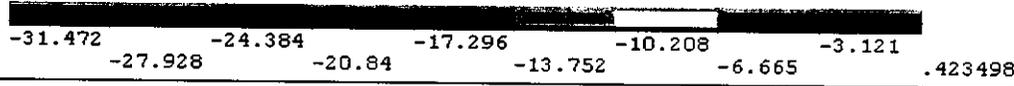
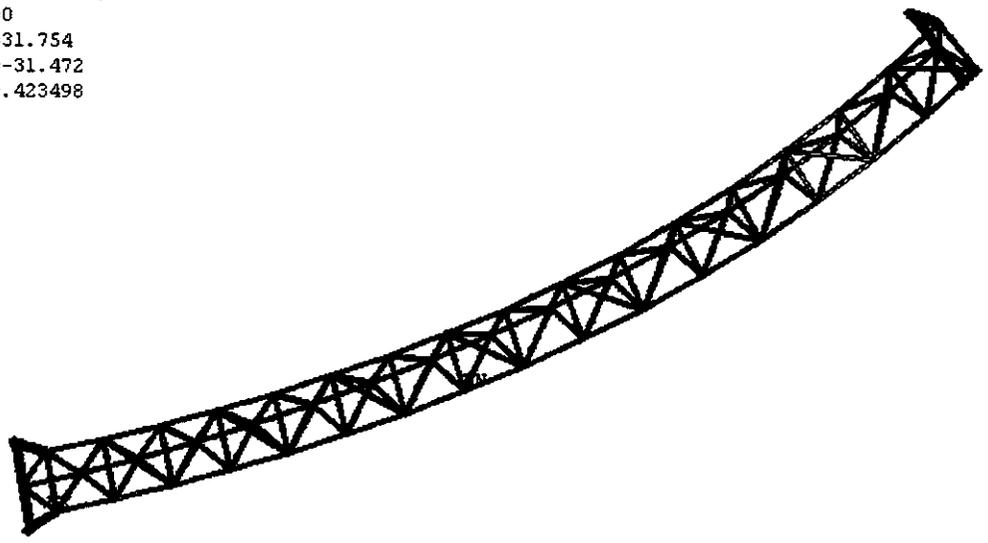
Loads and Boundary Conditions



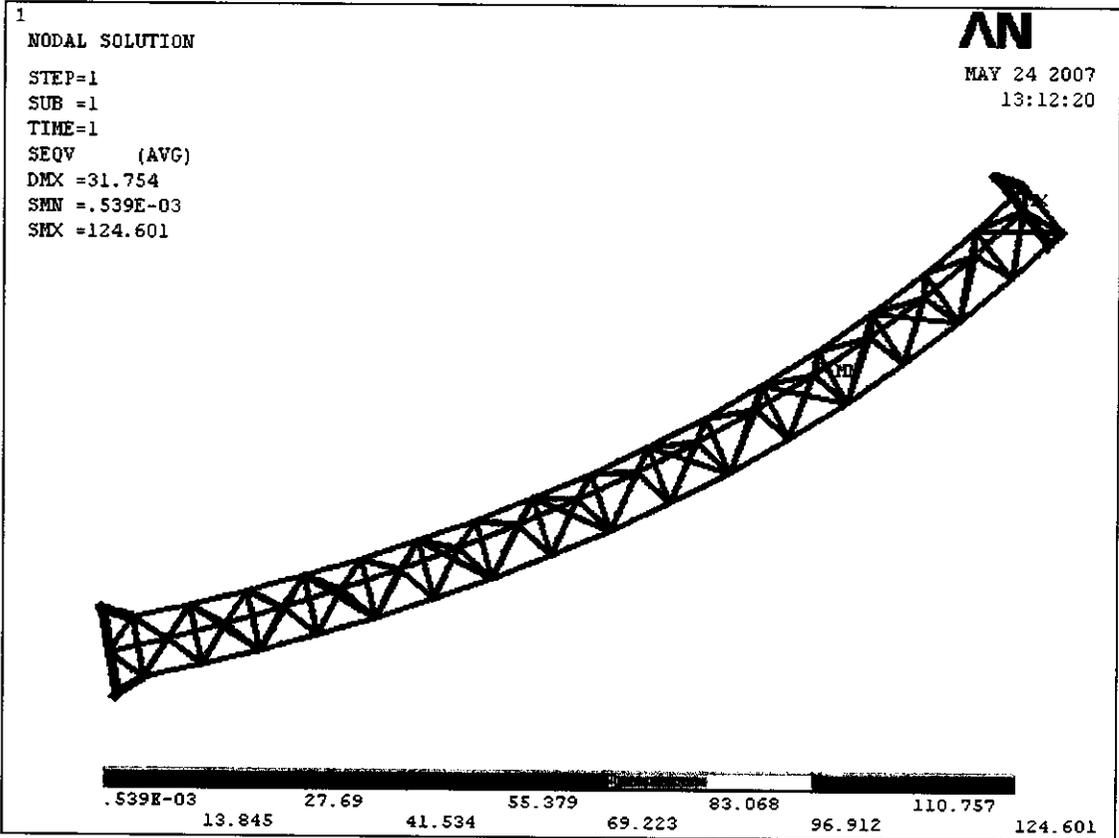
Deflection for Three sector

1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
UY (AVG)
RSYS=0
DMX =31.754
SMN =-31.472
SMX =.423498

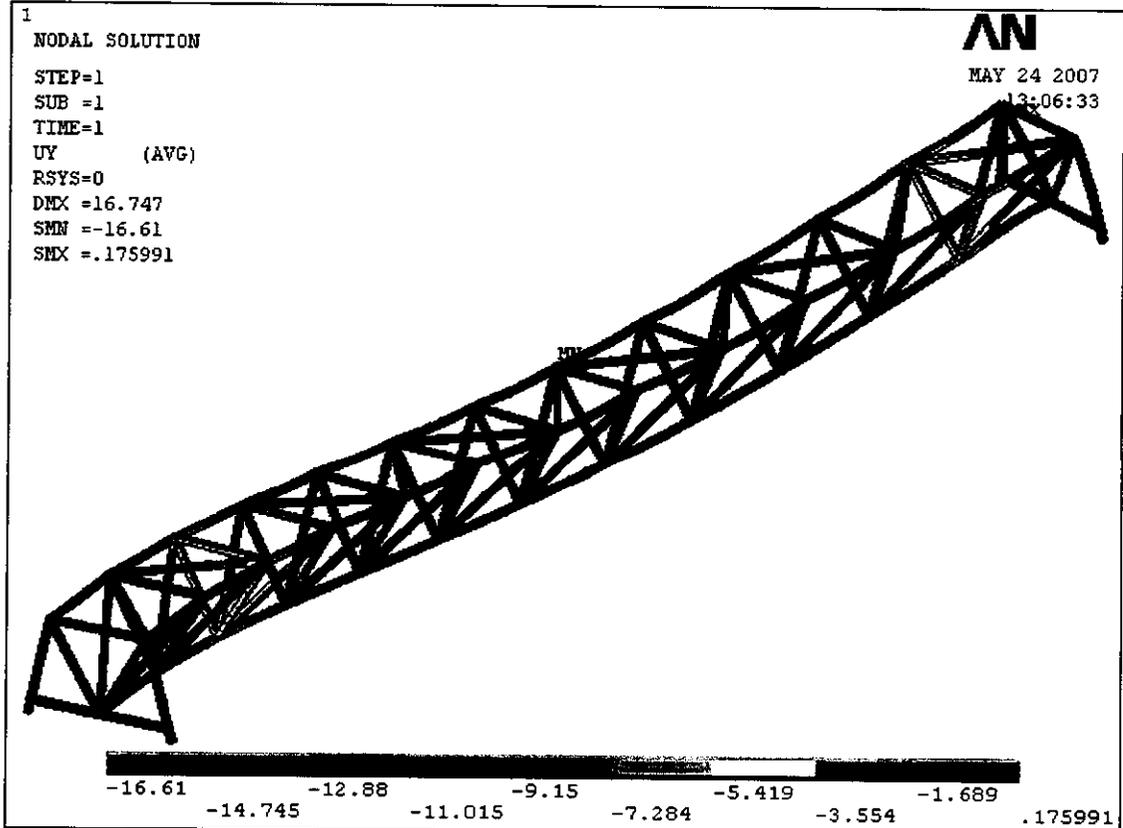
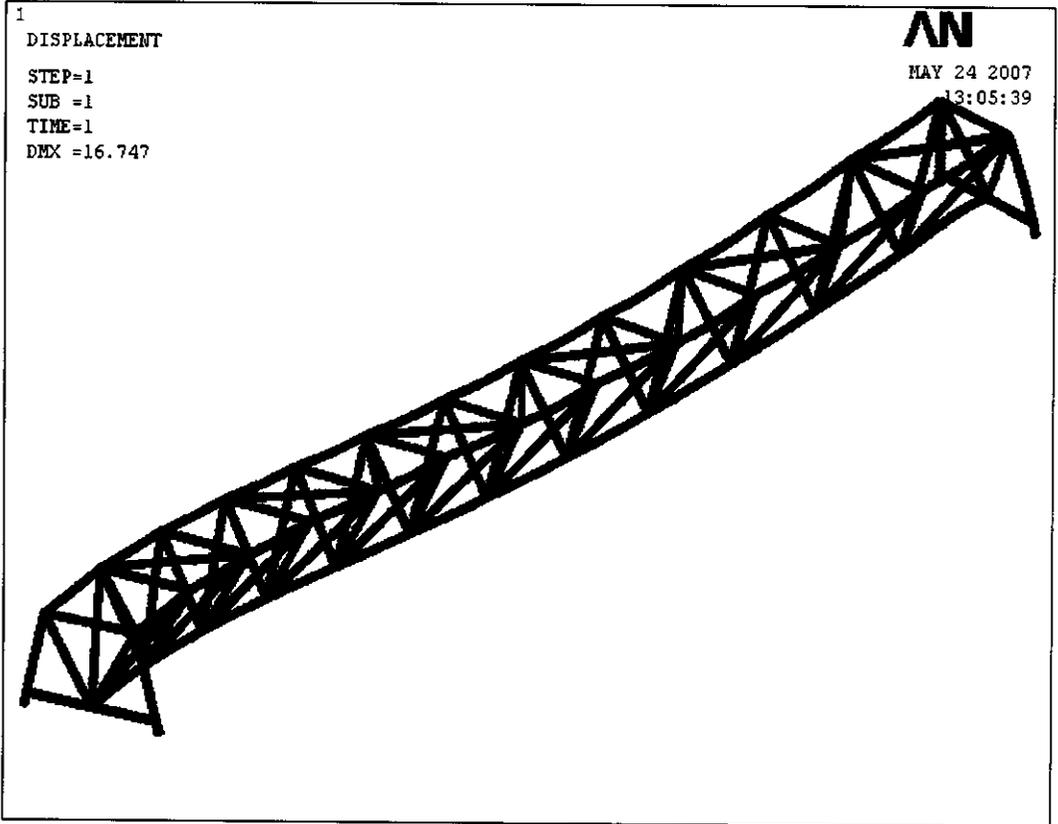
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Nodal Deflection



Von-Misses Equivalent Stress for four Sectors



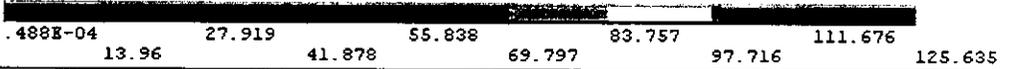
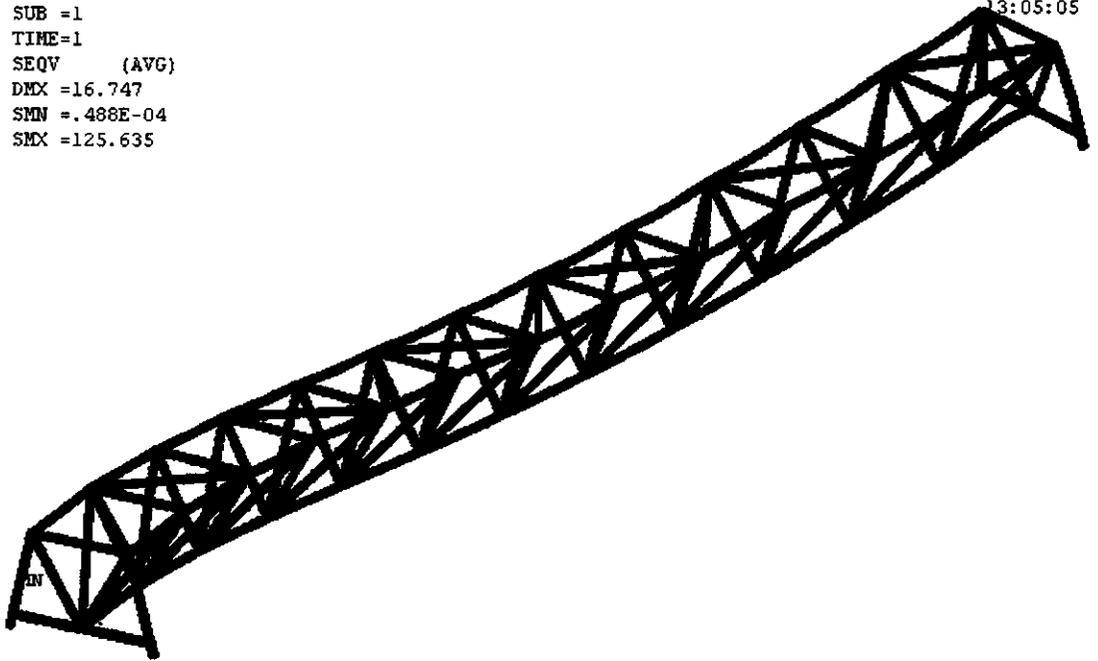
1

NODAL SOLUTION

STEP=1
SUB =1
TIME=1
SEQV (AVG)
DMX =16.747
SMN =.488E-04
SMX =125.635



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13:05:05



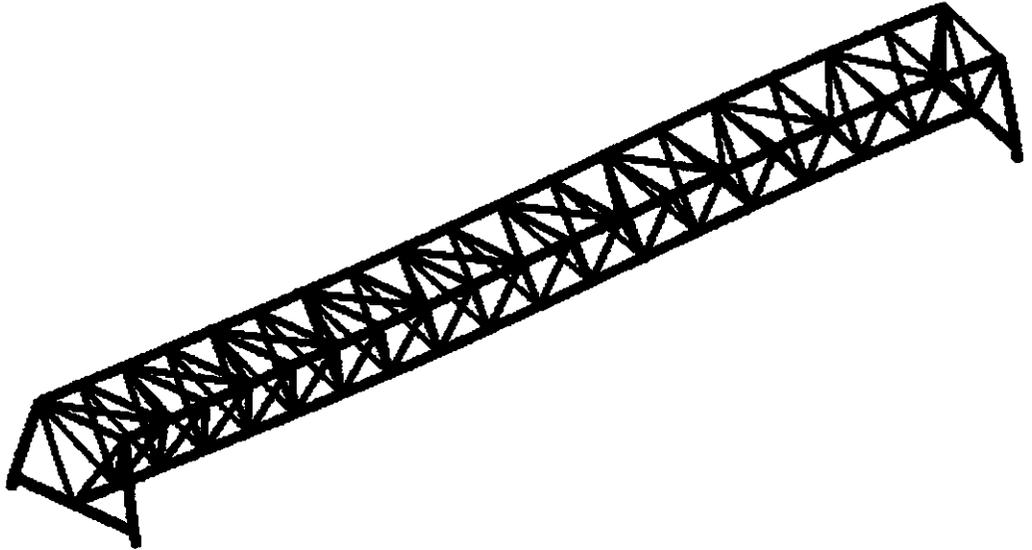
1

DISPLACEMENT

SUB =1
TIME=1
DMX =14.788



MAY 24 2007
12:53:47



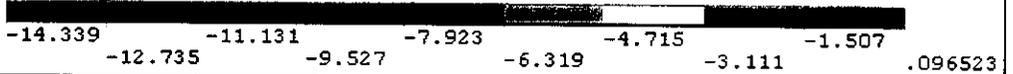
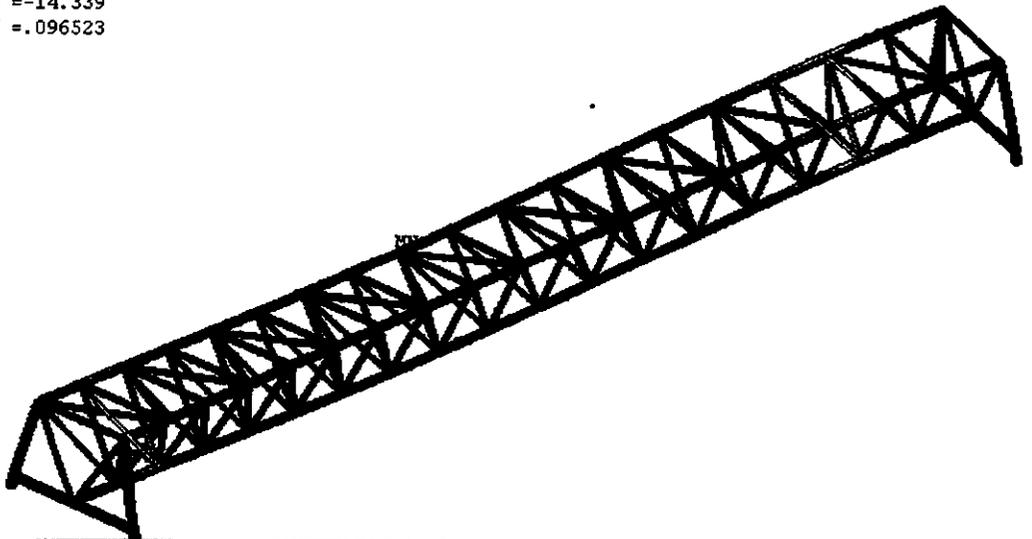
1

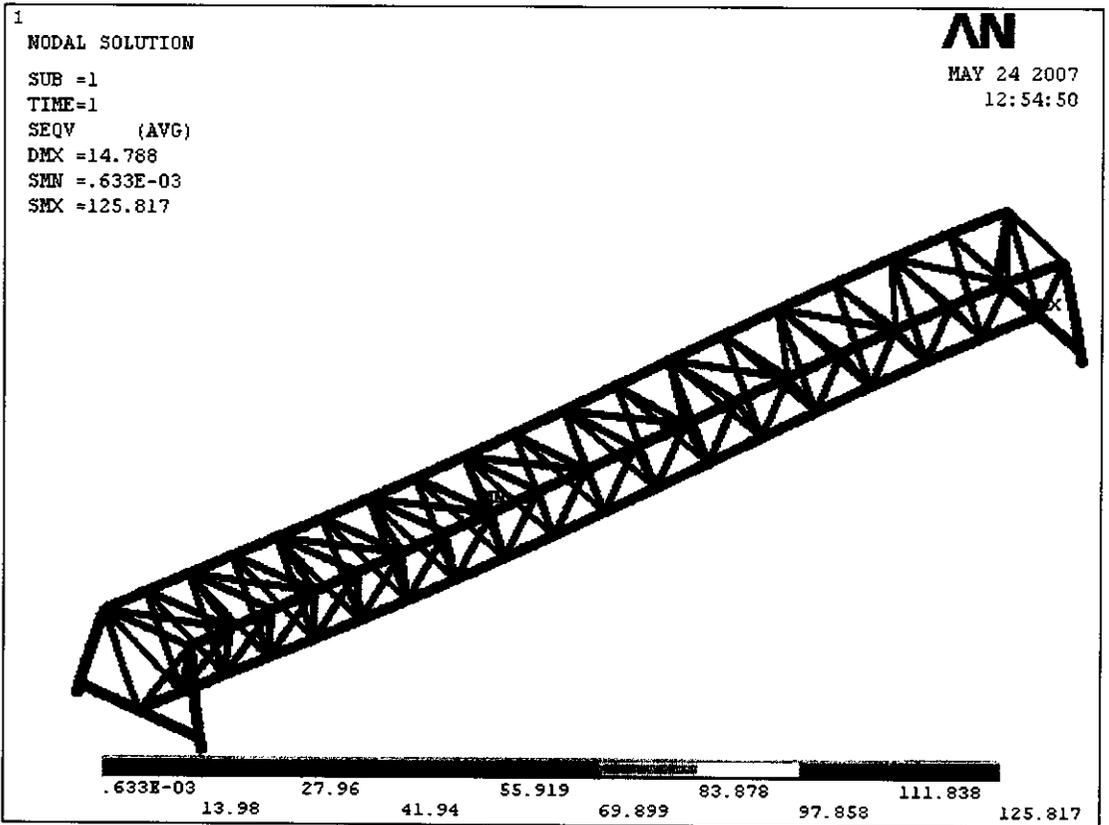
NODAL SOLUTION

SUB =1
TIME=1
UY (AVG)
RSYS=0
DMX =14.788
SMN =-14.339
SMX =.096523



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12:55:35





Von-Mises Equivalent Stress for Five Sectors

Chapter 6

Conclusion

CHAPTER 6 CONCLUSION

The following are the salient points that emerge from this investigation:

- Deflection depends upon pitch, if pitch increases, the deflection increases.
- Triangular Gantry brings the low cost and high strength compare to square geometry.
- Sector four is suitable for the best one.

Around 1 lakh rupees can be saved for each sectors and also reduce the material.

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