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Modeling and Analysis of Aqueduct using Staad. Pro

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Abstract - *Present paper deals with modeling and analysis of aqueduct structure in Staad. Pro. An attempt is made to model aqueduct in software and results are observed with given loading condition.*

Aqueduct is a cross drainage structure carrying canal supported with piers which concerned with river current. In the paper loading actiong on barrels and stresses are observed after analysis.

In the paper loadings are mainly acting on the barrels are considered to check behavior of the barrel. Seismic static loading is applied by the virtue of self weight and other loadings.

Key Words **:** Aqueduct, barrel, Hydrostatic loading, stresses, Earthquake loading

1. INTRODUCTION

Whenever a canal crosses a natural drainage on its passage it is necessary to construct masonry works to dispose of drainage discharge so that the canal water supply continues uninterrupted. These masonry works are termed as cross drainage works

Canal are generally aligned on the watershed so that they meet minimum number of drain. However, before watershed is reached, they usually cross a number of drainage lines. At the watershed itself cross a number of local drainage. A canal system taking off from a large river may irrigate area comprising a number of doabs or area between different streams.

In this paper under a fix set of input aqueduct is analysed as beam element and plate elements.

2. Types of Drainage Works

Drainage water intercepted by a canal may be disposed of by any one of the following method:

1. By passing the irrigation canal over the drainage .This is achieved through
   1. An aqueduct or
   2. A syphon aqueduct
2. By passing the drainage over the canal. This is achieved through:
   1. A super passage
   2. A syphon.
3. By passing the drainage through the canal so that the drainage and irrigation water are intermixed. This is affected by:
   1. A level crossing
   2. An inlet and outlet

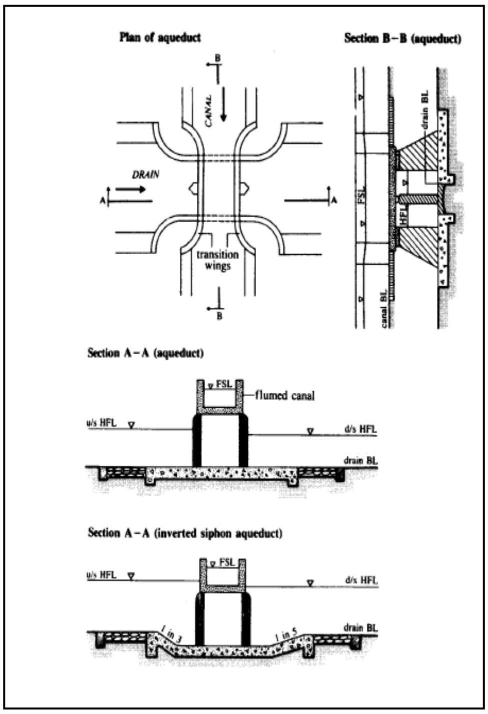


Fig -1: Aqueduct layout of structure

3. Input data and Design of aqueduct

In this section following is the manual design of aqueduct for the canal and drainage levels as described below:

i	Canal discharge	39.8 cumec
ii	Bed width of canal	13.0 m
iii	Water depth	2.4
iv	Total head loss	(entry 0.033,aqueduct 0.132m and exit 0.065m total 0.23m)
v	Upstream bed level of canal	70.97m

vi	Downstream bed level of canal	70.23-0.23=70.76
vii	Manning 's rugosity coefficient	0.016
viii	Side slope of canal	1.5:1
ix	Bed level of river	62.79m
x	Ground level on the u.s side of river bed	67.24m
xi	Ground level on d.s of river bed	66.875m
xii	Maximum flood level in river	71.16m
xiii	Maximum discharge in the river	1025m^3\s
Xiv	Maximum water table level at site	64.28m

Table -1: Input data

3.1 Design

Span between piers = 13.70 m
Span between bearing = 12.95m
Trough dimensions = 6*3.2
Free board = 0.8m
(i) Weight of upper and lower slab = 0.4*2.4=0.96 t\m
(ii) Water thrust at sides: water depth =2.8 m upto lower bed of trough; pressure =2.8t\m
(iii) Water load on bottom slab = 1*2.8*1=2.8 t\m
(iv) Weight of wearing coat 0.075*2.4 t/m
The maximum load as per IRC class A loading is (5.7 t per 1.83m)
For the design of trough section 5.7t AB=CD =6.4m; BC =AD =3.6. The load for maximum bending moment will be as per following fig.

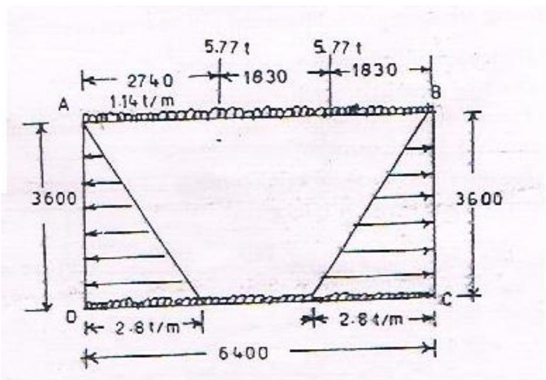


Fig -2: Load Diagram for the Barrel

(a) Member AB
B.M for uniformly distributed load;
$M_a = M_b = WL2/12 = 1.14*6.4^2/12 = 3.9$ tm
Calculation for point load B.M
$R_a = 5.7 * (5.49/6.4) = 4.$t
$R_b = 2*5.7 - 4.9 = 6.5$ t
$M_p = 4.9 * 2.74 = 13.4$ tm
$M_Q = 6.5 * 1.83 = 11.9$ tm

P is point of application of left 5.7 t
Q is point of application of right 5.7 t

By using of moment distribution method the calculating base and span moments due to concentrated and distributed loads we get moment and shear as below ;

Member	support	span	Shear force t
AB	10.283	9.46	10.31
BC	11.485	2.336	9.41
CD	11.485	8	12.1
DA	11.202	2.336	9.04

Table -2: Maximum moments and shear in different member of the box

3.2 Design of box section

Use of M20 concrete will be made ; permissible stress in concrete = 50 kg/cm2

Permissible stress in bending = 70kg/cm2 ; q = 7 kg/cm2 tor steel will be used

The following stresses in reinforcement will be taken in design

(i) Direct tensile strength = 1500 kg/cm2
(ii) Bending tensile strength = 1500kg/cm2
(iii) Tensile stress in member 225 mm or thick and away from water face ,in bending 1900 kg/cm2
(iv) Tensile stress in shear in shear reinforcement for member 225 mm or more in thickness under shear = 1750 kg/cm2

Modular ratio = 2800/3 * permissible stress in concrete in bending compression
= 2800/3*70=13.33 (IS 456)

Member	Face	Desired reinforcement	Provided reinforcement cm^2
AB	Inside	20.70 (span)	24.5
	Outside	17.5(support)	21.75
CD	Inside	25.2(support)	25.75
	Outside	13.5(span)	20.10
BC	Inside	25.2(support)	27.625
	Outside	3.95(span)	5.5
AD	Inside	25.2(support)	27.625
	Outside	3.95(span)	5.5

Table -3: Maximum moments and shear in different member of the box

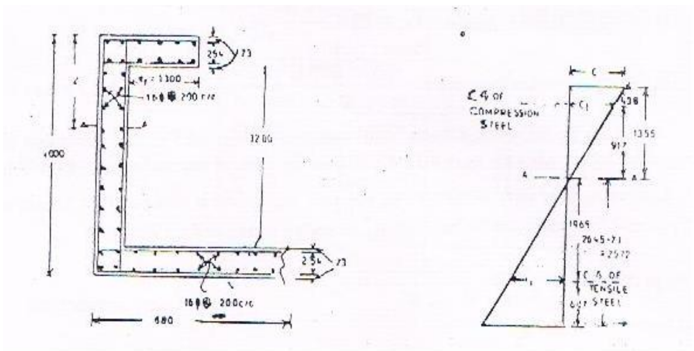


Fig -3: Reinforcement & Shear Diagram

4.ANALYSIS AND 3D MODELING

In this paper it is aimed to observe analysis results for fixed discharge and geometrical conditions

Modeling is carried out as per following:

(a) Taking geometry as beam element.

The solution of problem is derived by simplifying it as beam elements and analyzed under various loadings and according shear force and bending moment evaluated.

(b) Modeling the aqueduct with thre dimensional geometry.

In this action whole aqueduct is analyzed by modeling it under different loading condition and actual element such as plate and then analyses / design.

Loadings we taken or various element as described in IS 7784-1993 Part 1

4.1 Rectangular shape beam element

Fig -4: Rectangular model

4.3 Rectangular shape bending moment

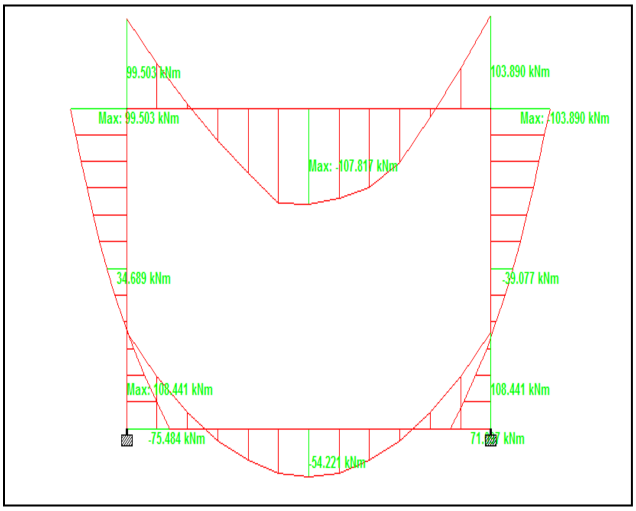


Fig -5: Bending moment

4.4 Trapezoidal shape

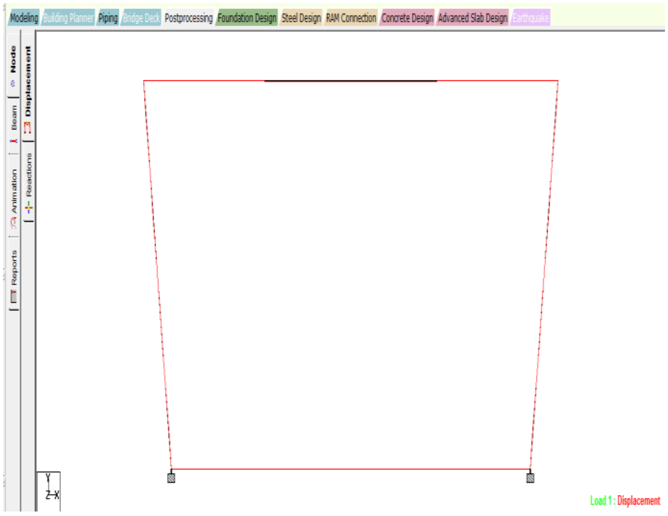


Fig -6: Trapezoidal model

4.5 Bending moment

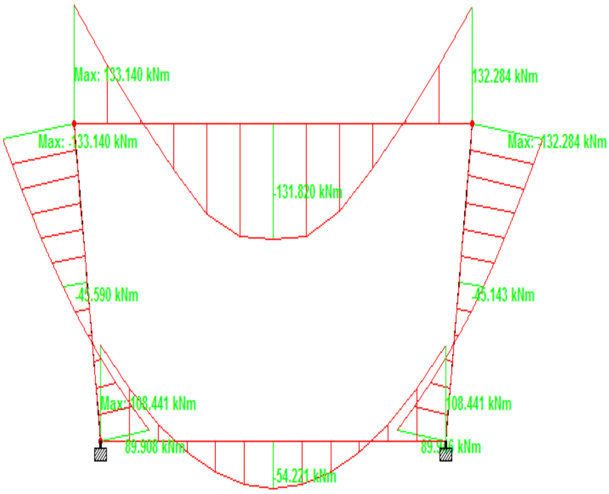


Fig -7: Bending moment

4.6 Analysis of rectangular shape Aqueduct with 3D modelling

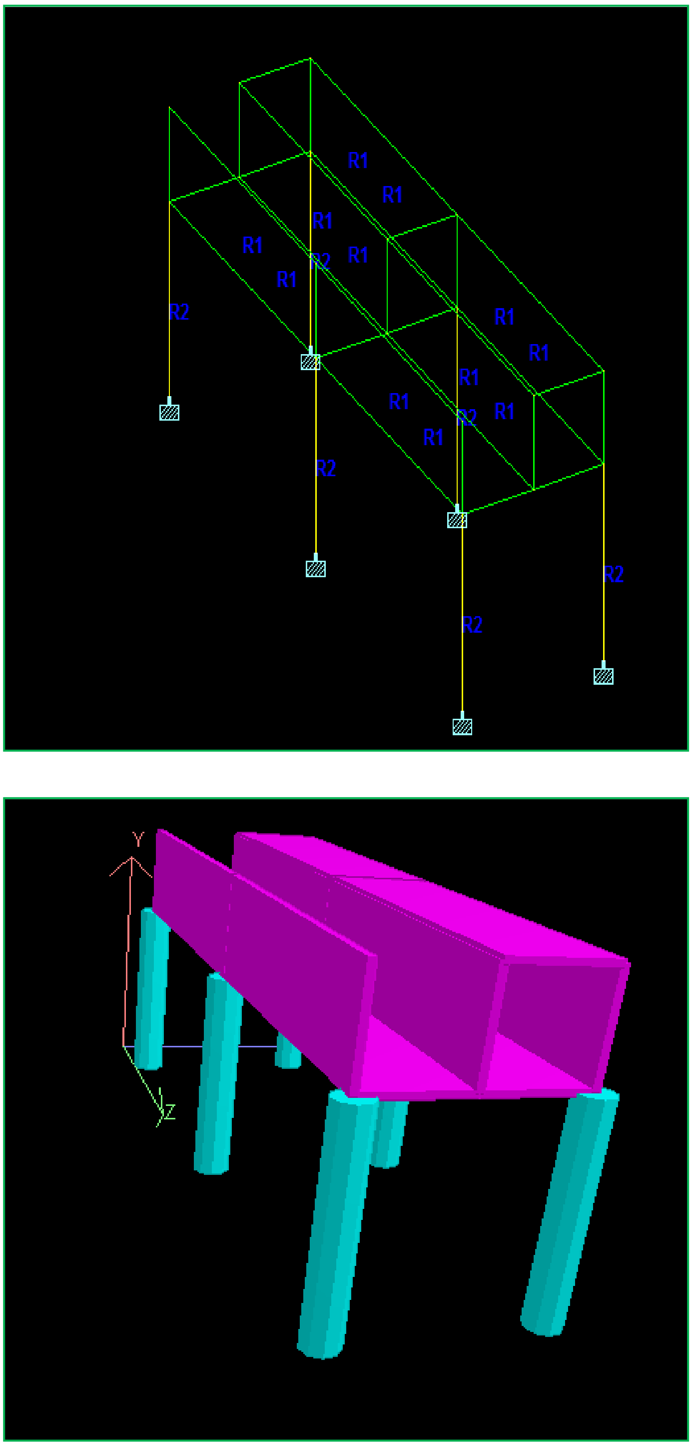


Fig -8: 3D render view of aqueduct

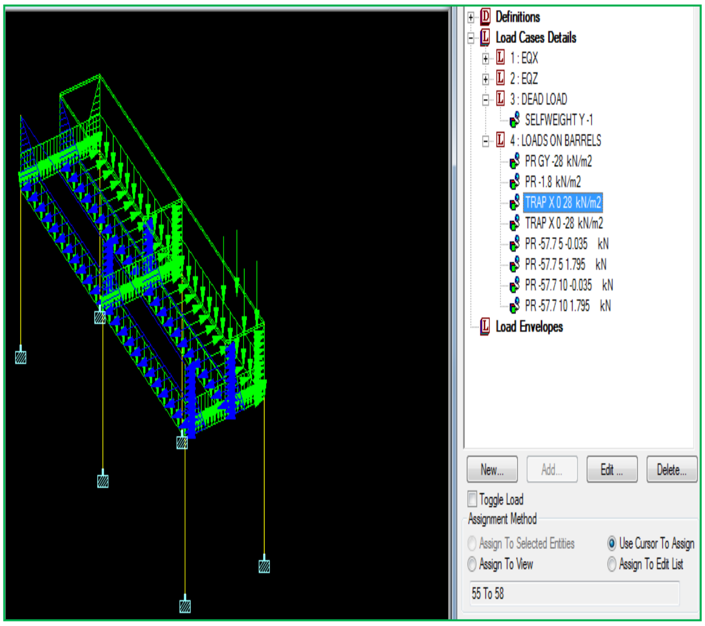


Fig -8: Load diagram

4.7 Plate stress

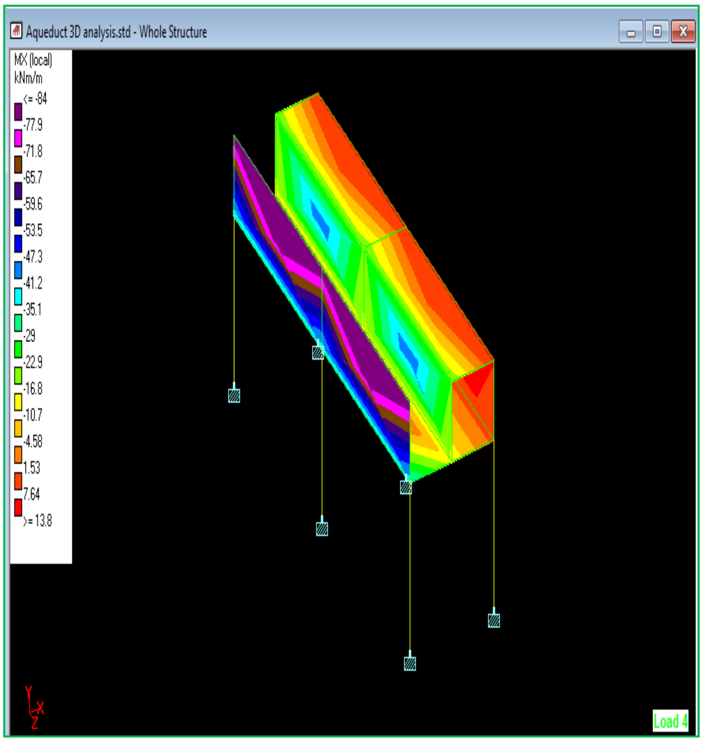
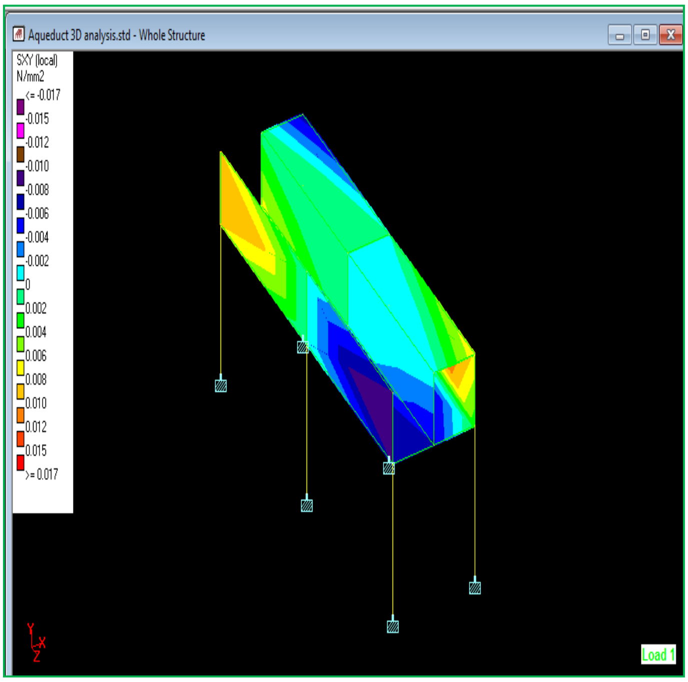


Fig -9: Plate stresses due to barrel loading

4.8 plate stresses



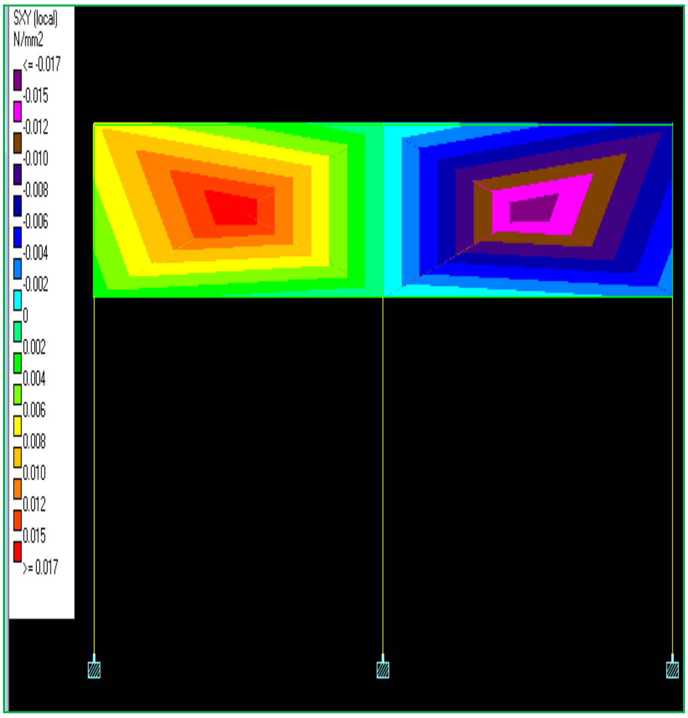


Fig -10: Plate stresses due to EQX + Loading

5.CONCLUSION

From the analysis, for the given data following points are concluded:

1. For rectangular cross section, Maximum moment is in top horizontal member as 107 kN.m (Sagging) and support moment as 108 kN.m (negative) in bottom member.
2. For Trapezoidal cross section, Maximum moment is in top horizontal member as 131 kN.m (Sagging) and support moment as 133 kN.m (negative)
3. In case of Bending stresses due to self weight, hydrostatic loading, Vehicular loads, it is observed that maximum stress concentration at centre in bottom slab is 1.53 kN m/m and minimum 0.29 kN m/m. Also free end of wall concentrated with 77.9 kN m/m at top portion.
4. In case of Shear stresses due to EQX loading, it is observed that maximum stress concentration in Right hand side wall at centre 0.015 kN m/m and minimum 0.012 kN m/m.

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