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Evaluation of Stability Analysis of Karjan Dam using safety factors

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Abstract:

A dam is a structure constructed across river which stores water and supplies water for various purposes.In this project, karjan dam is selected which are located near Jitgadh village in the NanodTaluka of Gujarat's Narmada District. The project area lies between 73◦5' and 73◦40' longitude east and 21◦31' & 22◦0' latitude north. In this paper, carry out a stability evaluation by manually, Matlab and Comsol 6.0 method. Dam break analysis and Dam sliding is done by comsol 6.0.Getting a negligible variation. The outcome will be getting such that the dam is safe next up to 70-90 years.

Key Words: Dam break analysis, Karjan dam, Comsol 6.0, Stability, Matlab.

Introduction:

- Dam is barrier constructed across the river to store the water. This stored water is useful for Domestic, Irrigation, Industrial, hydro electricity generation etc. Floods occur due to dam failure always dangerous for so it is necessary to analyse flood wave propagation at the downstream side of dam.
- In manually method, found out a principle stress, shear stress, pressure force, Momentum, F.O.S against overturning, sliding and shear friction, Resultant vertical force, resultant horizontal force,
- Comsol 6.0 is a finite element analysis, solver & simulation software or Finite Element Analysis software package for various physics and engineering applications.It is a powerful finite element, partial differential equation solution engine.
- There are many modules that expand in the following application areas such as a AC/DC module (For computational electromagnetics Modeling), Acoustics Module (For acoustics & vibrations analysis), Chemical Engg.(For modeling mass & energy balances & chemical reactions), Heat Transfer (For general purpose modeling of heat transfer in solids & fluids.),RF (For microwave & RF Design), MEMS (Micro Electromechanical Systems), Structural Mechanics, Plasma Module, Pipe flow Module, Battery Design Module.
- In project work, analysis of dam in 2D file as per solid mechanics from physics property.
- In this software, dam break analysis (Boundary condition) & dam sliding based on FEM method.

- There are two analysis to be carried out:

  (1) Dam Break Analysis (Boundary Condition) (2) Dam Sliding
- In Dam Break Analysis (Boundary Condition), Found out a velocity Magnitude, Total height, pressure.
- In Dam sliding, Found out a stress, displacement (Solid), Volume loads (Solid), boundary loads (Solid), Contact forces (Solid).
- Matlabis C++ & JAVA language codding related work. In this software, any type of structure cannot draw. It is a FEM related software. Can not a detailing design for any type of structure.
- Using matlab, found out a Principle stress, shear stress, sliding value with diagram and chart.

Objectives:

- To check out a stability of Karjan Dam using different techniques.
- To be carried out a dam break analysis using comsol 6.0.
- To be carried out a dam sliding using comsol 6.0.

Study area:

- The Karjan Reservoir Project is located near Jitagadh village in the NandodTaluka of Gujarat's Narmada District. River Karjan is left bank tributary of river Narmada. It is down stream of SardarSarovar Project. Through a left and right bank canal system, the project covers 51000 hectares of CCA. The project area lies on the western coast of the Indian continent, between 73°.5' and 73°.40' longitude east and 21°.30' and 22°.0' latitude north. The elevation of the project area varies between 18m to 120m above MSL.

Table-1: Salient features of Karjan Dam

Type	Masonry and Concrete
Maximum Height	100 m
Length at the Top of the dam	903 m
Top width of dam	7.77 m
Full Reservoir Level	115.25 m
Maximum Reservoir Level	116.10 m
Area at Full Reservoir Level	36.77 Km^2
Gross Storage Capacity	630 Mm^3
Effective Storage Capacity	581 Mm^3
Mean annual rainfall	1209 mm

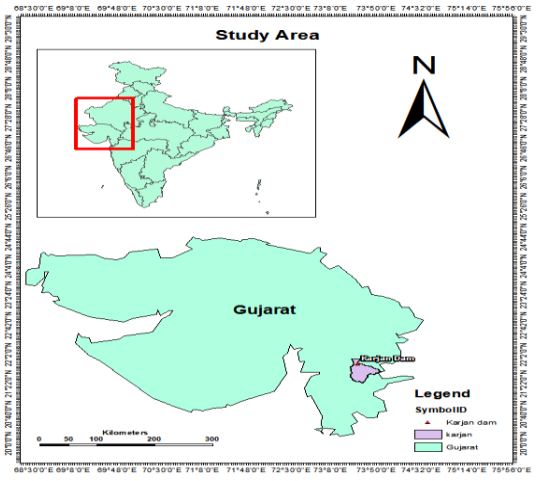

Figure-1: Study Area

Dam Geometry:

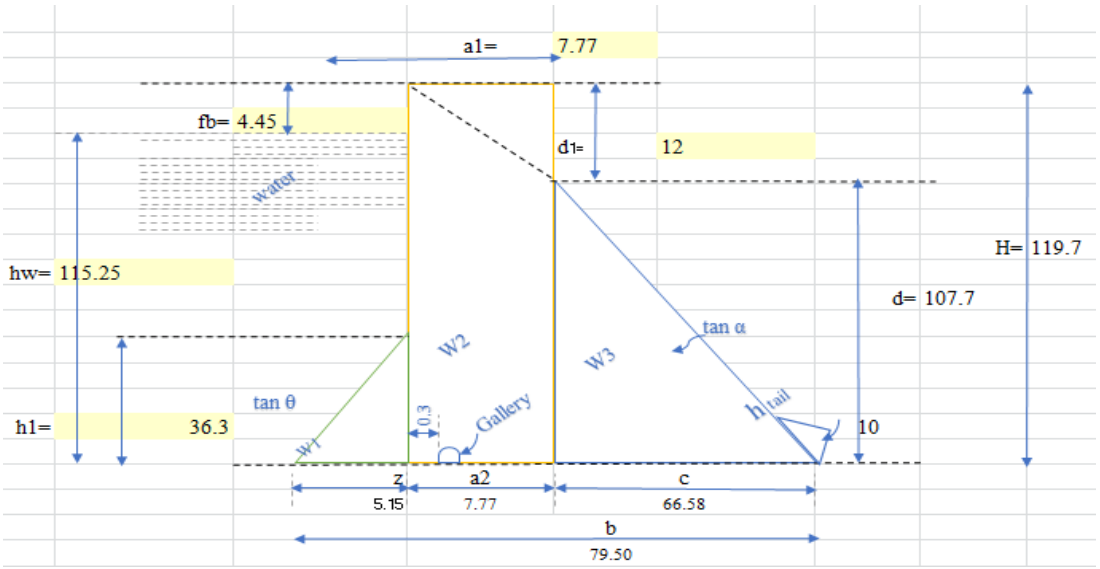

Figure-2: Cross Section Area

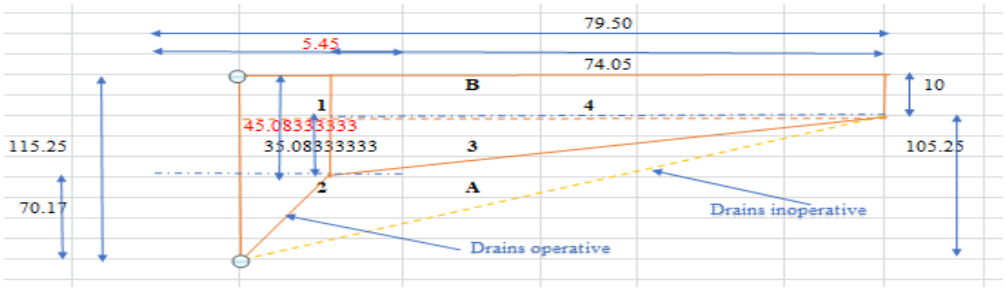

Figure-3: Uplift pressure head Diagram

Data collection and Analysis:

1. Manually

From government irrigation department, there are collected data related to dam and to be analyzed manually method. There are following analyzing table.

The following data are collected from Irrigation Department. Using following data, There are doing Stability check and various analysis. Matlab and Comsol software used for data collection analysis.

	Given Data:-		
1	Top widthW2(a1)	7.77	M
2	Bottom widthW2(a2)	7.77	M
3	Total heigth (H)	119.70	M
4	Reservoire water(hw)	115.25	M
5	Free bord(fb)	4.45	M
6	h1	36.30	M
7	z	5.15	M
8	W3(c)	66.58	M
9	Total base width (b)	79.50	M
10	d1	12.00	M
11	Coefficient of shear friction, μ (usual loading)	0.70	
12	Coefficient of shear friction, μ (extreme loading)	0.85	
13	shear strength at concrete-rock contact, C	150x10^6	N/m^2
14	weight density of water	1x10^4	N/m^3
15	weight density of concrete	2.4x10^4	N/m^3
16	weight density of sediment	1.36x10^4	N/m^4
17	Excess material density	1.925x10^4	N/m^5
18	Gallery distant	0.30	m
19	P=	960000	N/m^2
20	P'=	90000	N/m^2
21	α h	0.1	
22	α v	0.05	
23	w3(d)	107.7	M
24	Tail water depth(h tail)	10	M
25	Velocity Magnitude	0.778	m/s
26	Contact Force	2.0x 10^5	N/m^2
27	resistant force	6.0 x 10^4	N/m^2

Table:-2 FOS against various safety factor

Sr. No	Factor of Safety	90	Remarks	95	Remarks	100	Remarks	105	Remarks	110	Remarks	115.25	Remarks	119.7	Remarks
		mt	As per IS condition	mt	As per IS condition	mt	As per IS condition	mt	As per IS condition	mt	As per IS condition	mt	As per IS condition	mt	As per IS condition
	1	2	3	4	5	6	7	8	9	10	11	14	15	16	17
(A)	Usual loading														
i	Overturning	2.62	Safe	2.36	Safe	2.12	Safe	1.92	Safe	1.74	Safe	1.57	Safe	1.56	safe
ii	Sliding	1.72	Safe	1.52	Safe	1.36	Safe	1.22	Safe	1.10	Safe	1.00	Safe	1	safe
iii	Shear Friction	4.82	Safe	4.30	Safe	3.85	Safe	3.47	Safe	3.15	Safe	3	Safe	3	safe
(B)	Extreme loading														
i	Overturning	2.10	Safe	1.93	Safe	1.78	Safe	1.64	Safe	1.51	Safe	1.75	Safe	1.5	safe
ii	Sliding	1.77	Safe	1.61	Safe	1.48	Safe	1.35	Safe	1.24	Safe	1.44	Safe	1.2	safe
iii	Shear Friction	3.18	Safe	4.41	Safe	4.05	Safe	3.72	Safe	3.44	Safe	3.31	Safe	3.10	Safe

2. Analysed Using Matlab

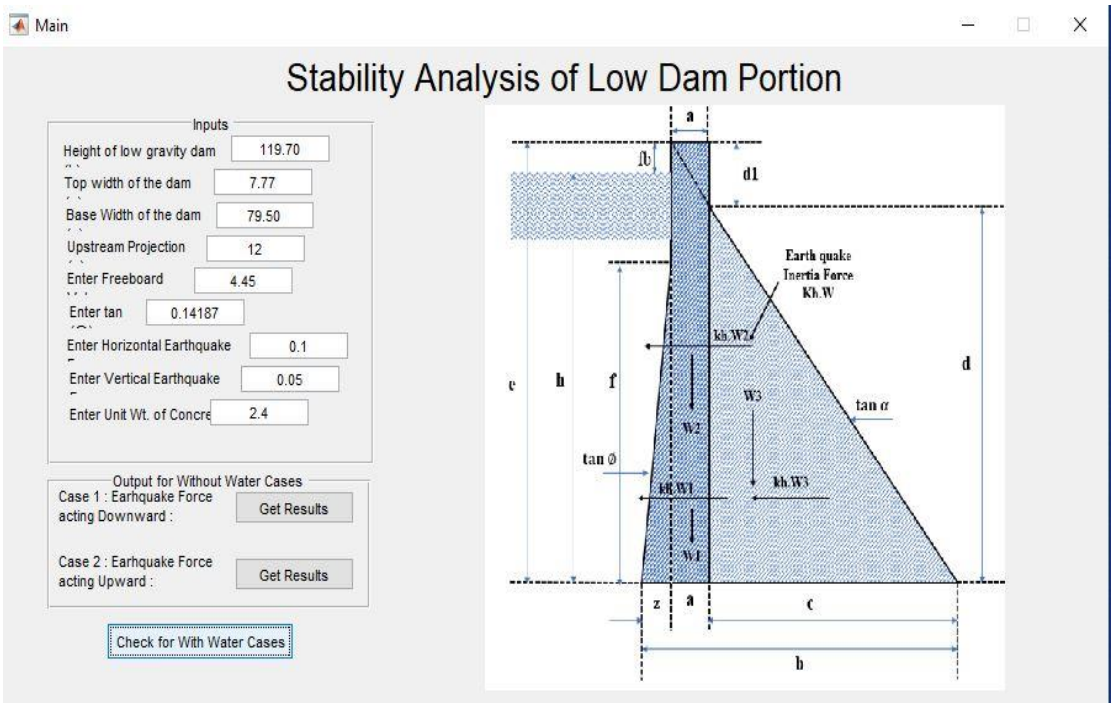

Figure:4 Stability analysis using matlab

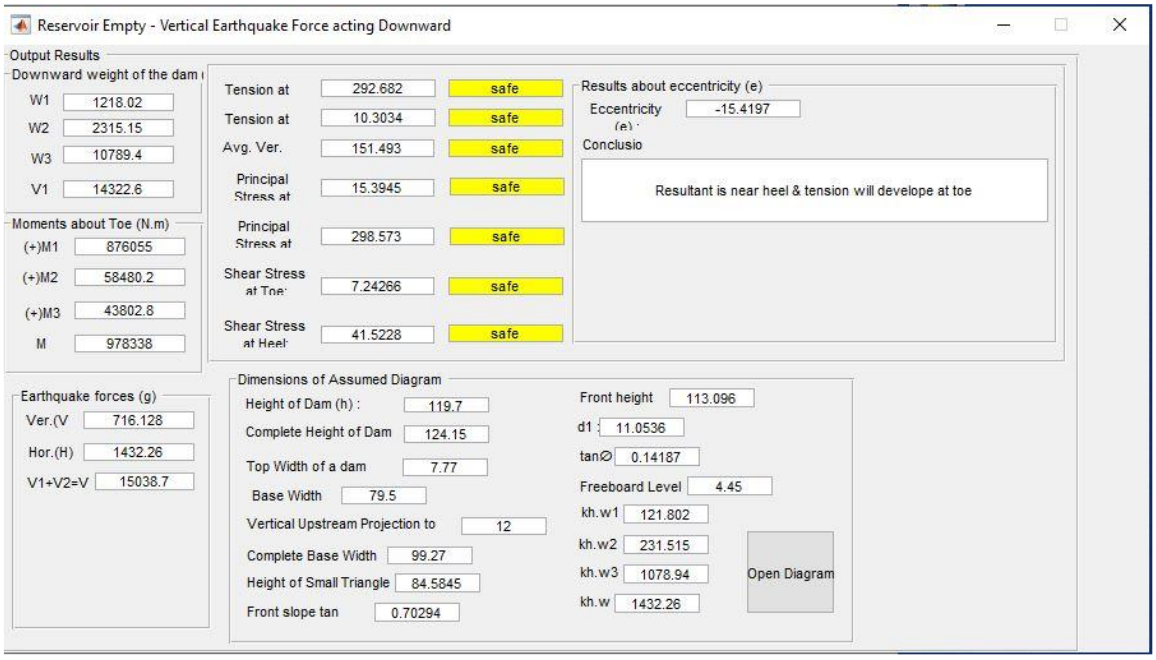

Figure:5 Stability analysis with reservoir empty condition and upward force using matlab

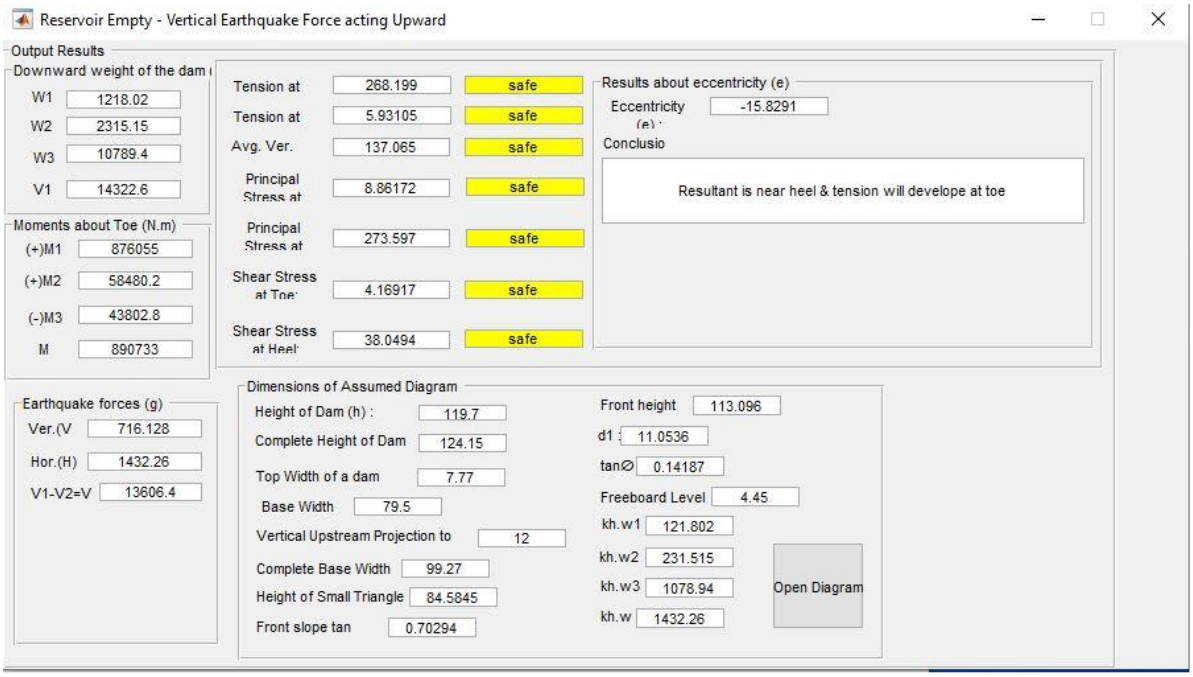

Figure:6 Stability analysis with reservoir empty condition and downward force using matlab

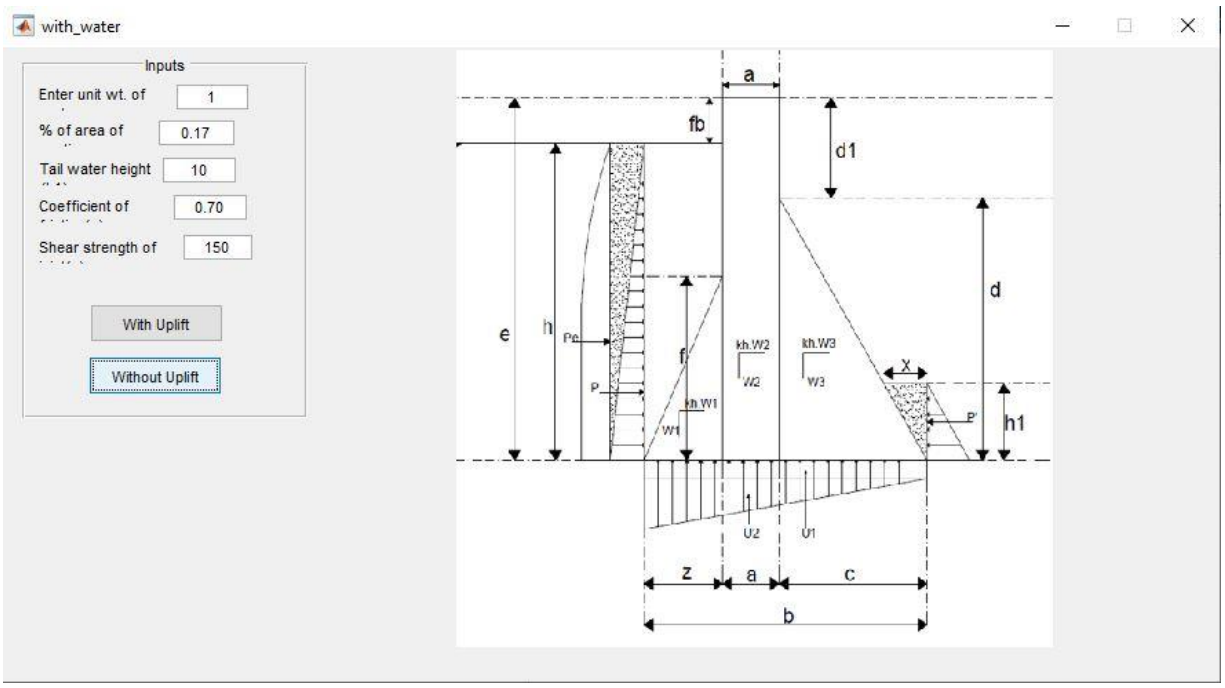

Figure:7 Stability analysis with water using matlab

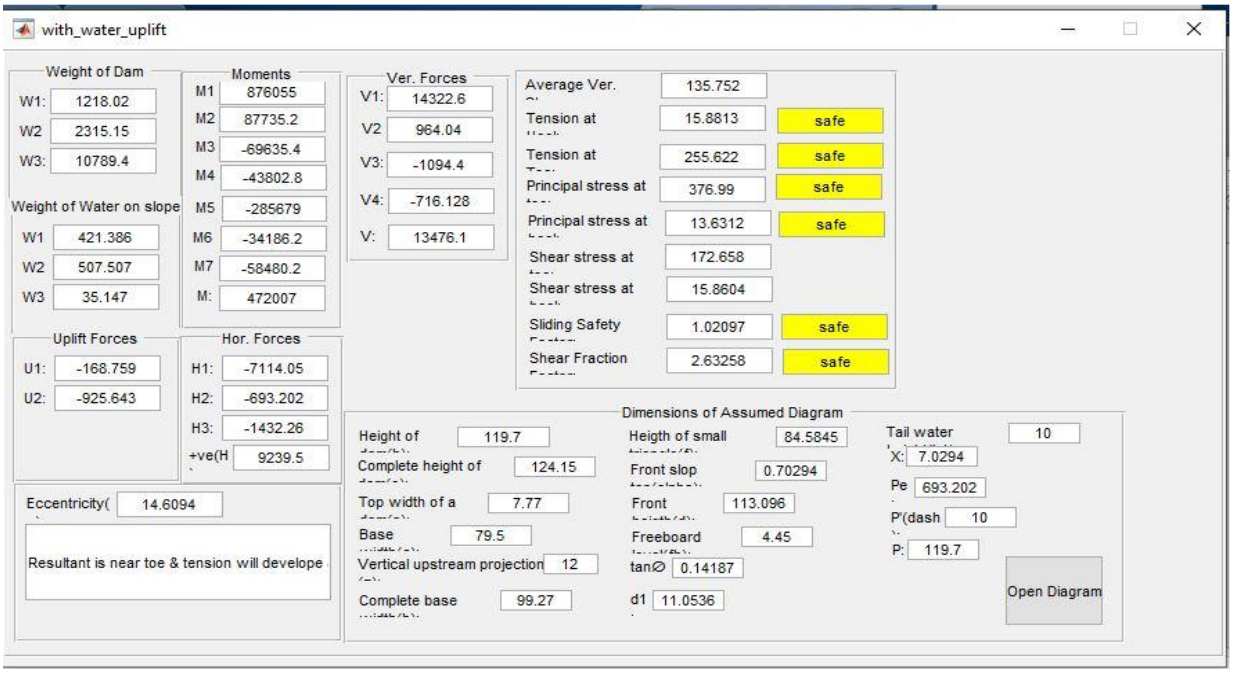

Figure:8 Stability analysis with water uplift using matlab

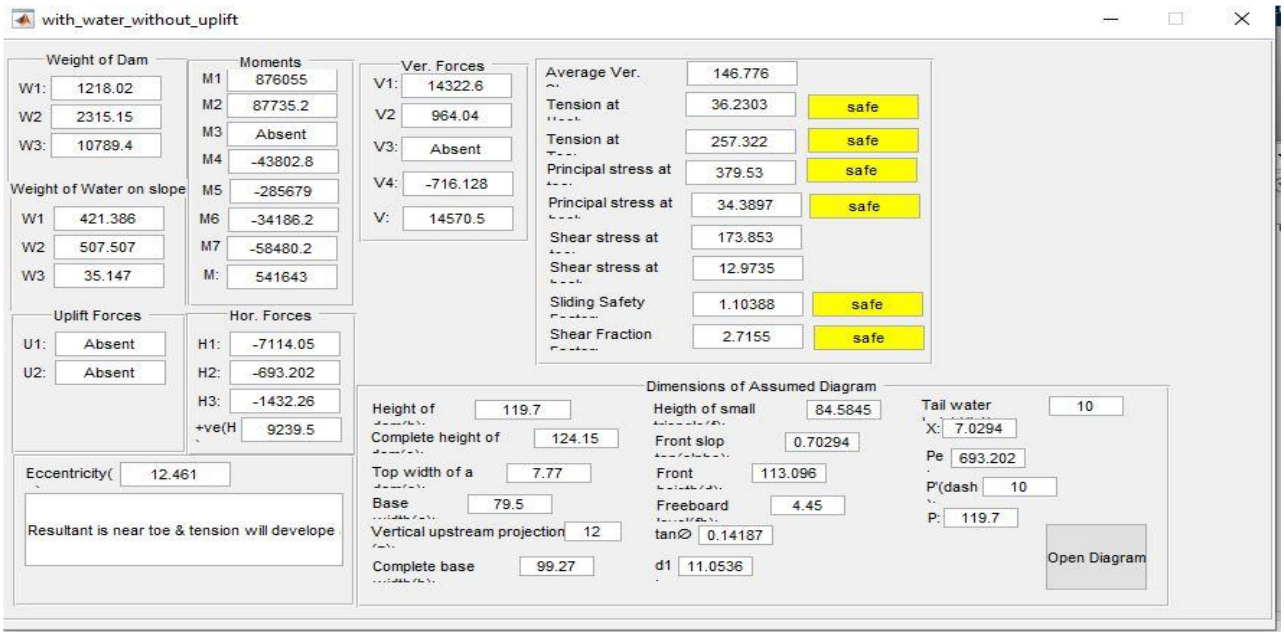

Figure:9 Stability analysis with water without uplift using matlab

Using comsol 6.0, there are carried out a two analysis. (1) Dam break analysis (2) Dam sliding.

In Dam break Analysis, there are found out a velocity magnitude, Total Height and Time vs Pressure force diagram. This chart show max velocity magnitude seems on which portion of Dam.

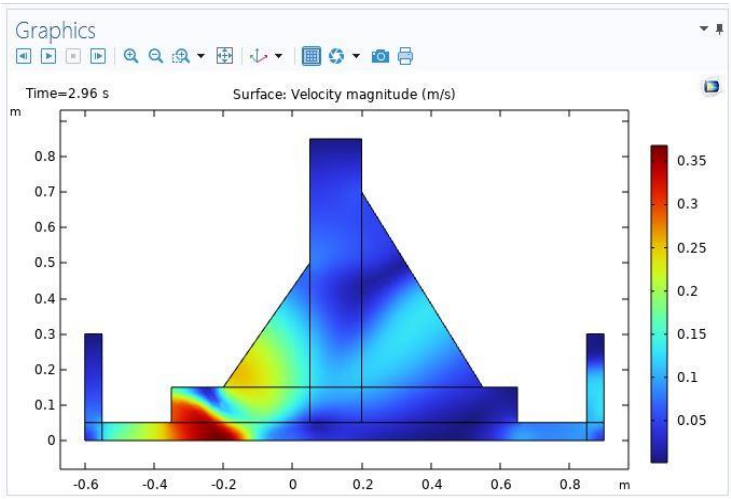

Figure:10 Velocity Magnitude

Using following equation, found out a velocity magnitude:

$$\frac{\partial h}{\partial t} + \nabla.\Gamma h = 0, h = h$$

$$\frac{\partial hu}{\partial t} + \nabla.\Gamma q = -gh\nabla hb + F, hu = q$$

$$\Gamma h = hu$$

$$\Gamma q = hu \otimes u + g.\frac{h^2}{2} i$$

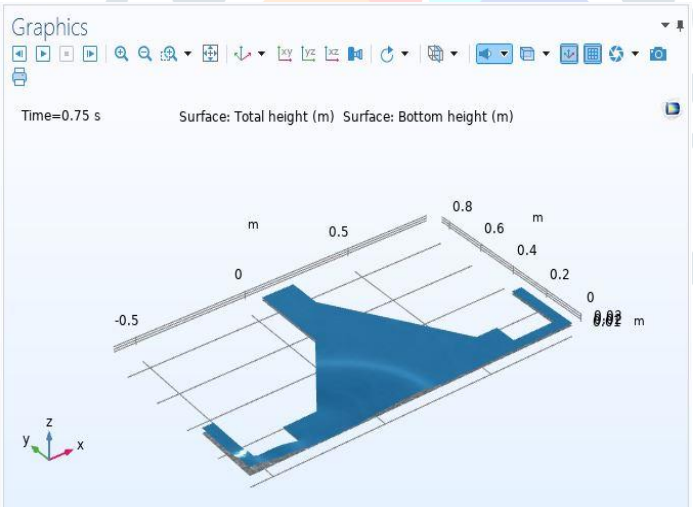

Figure:11 Total Height (SWE)

This chart show effect of water on different heights of dam at u/s.

Using following equation, found out a Total Height:

$$u.n = 0$$

$$-\Gamma h.n = 0$$

$$-\Gamma q.n = g.\frac{h^2}{2}$$

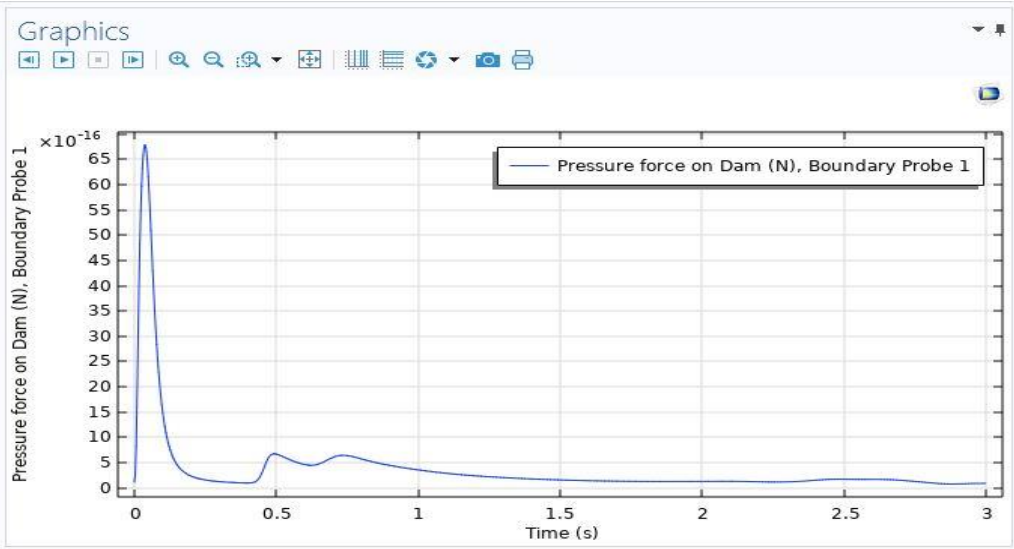

Figure:12 Time vs Pressure force diagram

From chart, max pressure force act on u/s portion of dam in beginning time. After that, pressure force gradually decreasing.

In Dam sliding, there are found out a Boundary loads, Contact forces, Displacement (Solid), Stress (Solid), Volume loads.

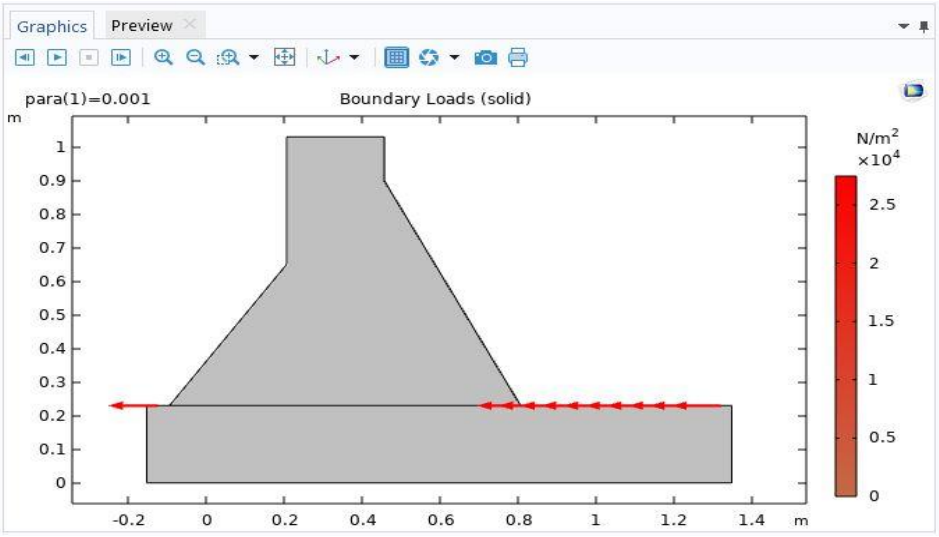

Figure:13 Boundary loads

Using following equation, found out a boundary load (Solid).

$$S \cdot n = F_A$$

$$F_A = \frac{Ftot}{A}$$

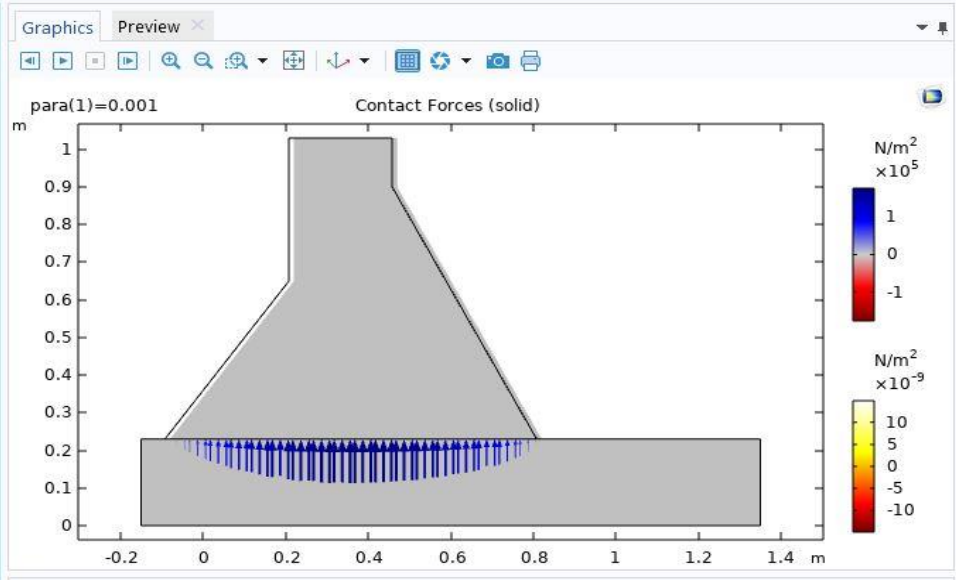

Figure:14 Contact force.

Using following equation, found out a boundary load (Solid).

Tn = if (gn ≤ 0, -pn.gn, 0)

$p_n = f_p \frac{Echar}{hmin}$

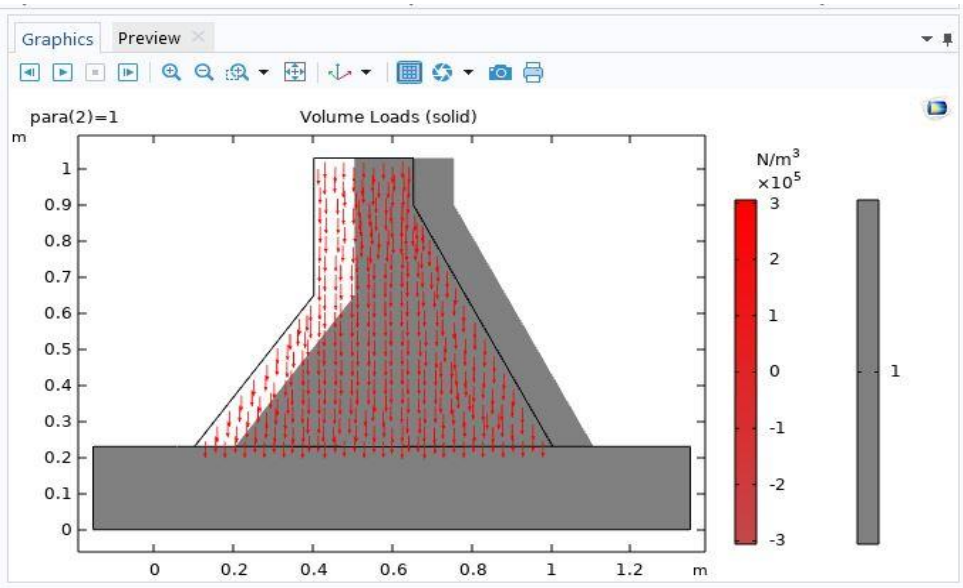

Figure:15 Volume loads

Using following equation, found out a Volume loads(Solid).

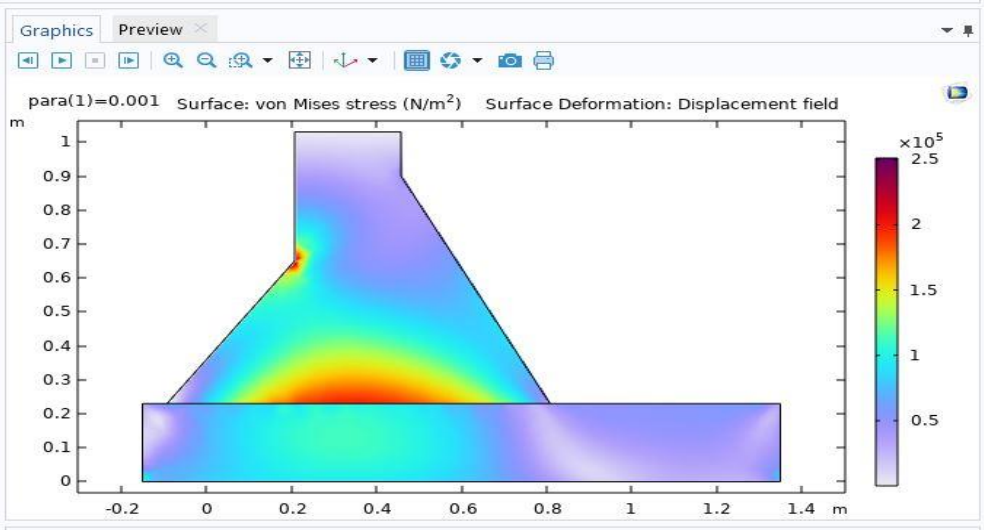

Figure:16 Principle Stress

Using following equation, found out a principle (Solid).

$0 = \nabla . (FS)^T + Fv, \quad F = I + \nabla u$

$Fv = \frac{Ftot}{V}$

Results:

In manually, After analysed and checked, getting a value is a safe against overturning, sliding and shear friction.

As per Is Code 6512 1984 Pg no 14	
Usual loading	
Overturning	1.5
Sliding	1
Shear Friction	>3.0 to <5.0
Extreme loading	
Overturning	1.5
Sliding	1.2
Shear Friction	>3.0 to <5.0

In Dam break analysis:

- Velocity magnitude is found out by linear langrage method. Getting maximum value is 0.35 m/s. and minimum value is 0.05 m/s.

- Total height is found out by Range kutta method. There are getting a maximum height 0.25778 m. and minimum height 0.13850 m. which are effecting on body of dam at u/s above F.S.L.
- There are found out a pressure force by Rangekutta method. Getting a maximum, middle, minimum value are 6.78 x 10^-15N, 1.75 x 10^-16 N and 7.79 x 10^-17 N respectively.

In Dam Sliding:

- Boundary loads is found out by quadratic serendipity method. In this chart, getting a dam resistance effect which is 3.0 x 10^4 N/m^2.
- Contact force is found out by quadratic serendipity method. Getting a maximum value is 1 x 10^5 N/m^2.Which show resistance force of dam.
- Principle stress is found out by quadratic serendipity method. Getting a maximum and minimum value are 1.917 x 10^5 N/m^2and1 x 10^5 N/m^2 respectively.
- Volume load is found out by quadratic serendipity method. Its value is obtained a 3 x 10^5 N/m^3

Conclusion

- As per Is code: 6512-1984 limitation, There are analyzed of overturning, sliding and shear friction at 90m to 115.25m (FSL) & 119.70m (full height of Dam) with 5 m interval in case of usual load & Extreme load. As per analyzed results, Karjan dam is safe.
- As per Finite Element Method, using comsol 6.0 version, it has been analyzed of dam break analysis (Boundary condition for 2-D) with visualization effects such as velocity magnitude, Pressure force (time vs. pressure force for 3 second), Total height. As per obtained results, dam is seem to safe.
- As per Finite Element Method, using comsol 6.0 version, it has been analyzed of dam sliding analysis (2-D) with visualization effects such as boundary load (Resisting force), contact force, displacement, principal stress. As per obtained results, dam is seem to safe.
- After stability analysis of dam using Matlab, Dam is seems to safe for case-1 without water (Usual load) and case-2 with water (Extreme load).
- Finally, after all analysis of Dam with respect to stability and flood, Karjan Dam is appear safe up to next 70 to 90 years. But, in order to proper stability of dam, it is necessary to carry out periodic maintenance as per the required guidance of government.

Evaluation of Stability Analysis of Karjan Dam by manually and software

Analysis	Principal Stress (N/m^2)	Sliding value	Pressure force(T vs.N)	Velocity Magnitude (m/s)	Contact Force (N/m^2)	Shear stress at toe (N/m^2)	Total Moment (N.m)	Resistant force
Manual	3.48 x 10^5	1.0	1.28 x 10^-8	0.778 (As per Gov.data)	2.0x 10^5 (As per Gov.data)	1.52 x 10^6	4.32 x 10^5	6.0 x 10^4 (As per Gov.data)
Matlab	3.76 x 10^5	1.02	----------	----------	--------	1.72 x 10^6	4.72 x 10^5	----------
Comsol	3.46 x 10^5	1.0	1.05 x 10^-8	0.6336	1.81*10^5	----------	----------	5.43x 10^4

References

1) **Dam Break Analysis (Boundary Condition) Comsol Multiphasic software 5.6 Manual (www.comsol.com/trademarks.)**
2) **Sliding Wedge Comsol Multiphasic software 5.5 Manual (www.comsol.com/trademarks.)**
3) **Standards/Manuals/ Guidelines For Small Hydro Development.**
4) **Irrigation and Water resources Engineering,**
5) **"Thermally-induced cracking of a concrete arch dam using COMSOL Multi physics" Tobias Gasch, Daniel Ericsson May-2017**
6) **"Stress and Deformation Analysis of High Concrete Face Rockfill Dam Based on COMSOL Multiphysics." Wang and Keping Yu January-2013**
7) **"Sedimentation Optimization on River Dam Flow by Using COMSOL Multiphysics." Tulus, Marpung August-2018**
8) **"Development of Methodology for Seismic Design of Concrete Gravity Dam" Pratik Patra, Odisha May-2014**
9) **"A Comparative Study of Design of Dam". Priyadarshini Maitra1 et all, Mukutmanipur, Kolkata May-2019.**
10) **"On the Dynamic Capacity of Concrete Dams" Furgani1 et al. (MDPI) August-2019.**
11) **"Seismic Forces and Stability Analysis of Gravity Dam" VenkataRajuBadanapur Volume 8 Issue 6, June 2019**