Analysis of Circular Culvert Constructed across with and without Geotextile Embankment using Ansys Software

Neenu K Baby[1], Prof.Raghunandan Kumar R[2], Prof Dr.Lovely K.M[3]
[1]Mtech Student, Department of Civil Engineering, Mar Baselios Institute of Technology & Science, Nellimattom
[2]Research Scholar, Department of Civil Engineering, Christ University, banglore
[3]Professor, Department of Civil Engineering, Mar Baselios Institute of Technology & Science, Nellimattom

***Abstract* - Basically, a culvert means a covered hydraulic structure which conveys fluid. Culverts are available in many sizes and shapes including round, elliptical, flat-bottomed, pear-shaped, and box-like constructions. In this paper, only take the circular culvert. The culvert type and shape selection is based on a number of factors including: requirements for hydraulic performance, limitation on upstream water surface elevation, and roadway embankment height.Therefore in a broad sense, pipe culverts in a small scale represent normal pipes like precast concrete pipes. Culvert is idealy suited for a road or railway bridge crossing a screen with a limited flow. Box culverts are economical due to their rigidity and monolithic action and separate foundations are not required. Culvert failures can occur for a wide variety of reasons including; maintenance, environmental, and installation related failures, functional or process failures related to capacity and volume causing the erosion of the soil around or under them, and structural or material failures that cause culverts to fail due to collapse or corrosion of the materials from which they are made. If the failure is sudden, it can result in injury or loss of life. Sudden road collapses are often at poorly designed and engineered culvert crossing sites. Water passing through undersized culverts will scour away the surrounding soil over time. This can cause a sudden failure during medium-sized rain events. There are more than 5,000,000 culverts currently in use in the United States alone. Continued inspection, maintenance, and replacement of these structures is crucial for infrastructure and safety. Accidents due to culvert failure can also occur if a culvert has not been adequately sized and a flood event overwhelms the culvert, or disrupts the road or railway above it. Ongoing culvert function without failure depends on proper design and engineering considerations being given to load and water capacities, surrounding soil analysis, backfill and bedding compaction, and erosion protection. So, geotextile is used in the embankment. Result of analysis indicate that one of the primary function of geotextile was to reduce the horizontal displacement significantly. Also it is observed from the obtained result that stress and displacement for circular culvert construced across with geotextile embankment is less than stress and displacement for circular culvert across without geotextile embankment.**

Index Terms – **Embankment, Culvert, Geotextile, Circular Culvert, Soil Properties**

1. INTRODUCTION

A culvert is a structure that allows water to flow under a road, railroad, trail, or similar obstruction from one side to the other side. Typically embedded so as to be surrounded by soil, a culvert may be made from a pipe, reinforced concrete or other material. A structure that carries water above land is known as an aqueduct. Culverts are commonly used both as cross-drains for ditch relief and to pass water under a road at natural drainage and stream crossings. A culvert may be a bridge-like structure designed to allow vehicle or pedestrian traffic to cross over the waterway while allowing adequate passage for the water. Culverts come in many sizes and shapes including round, elliptical, flat-bottomed, pear-shaped, and box-like constructions. The culvert type and shape selection is based on a number of factors including: requirements for hydraulic performance, limitation on upstream water surface elevation, and roadway embankment height.

Construction or installation at a culvert site generally results in disturbance of the site soil, stream banks, or streambed, and can result in the occurrence of unwanted problems such as scour holes or slumping of banks adjacent to the culvert structure.[2][3] Culverts must also be properly sized and installed, and protected from erosion and scour. Many agencies such as U.S. Department of Transportation Federal Highway Administration (FHWA), Bureau of Land Management (BLM),[4] and U.S. Environmental Protection Agency (EPA)[5] as well as state or local authorities [6] require that culverts be designed and engineered to meet specific Federal, State, or local regulations and guidelines to ensure proper function and protect against culvert failures. Culverts are classified by standards for their load capacities, water flow capacities, life spans, and installation requirements for bedding and backfill.[7] Most agencies adhere to these standards when designing, engineering, and specifying culverts.

Accidents due to culvert failure

Culvert failures can occur for a wide variety of reasons including; maintenance, environmental, and installation related failures, functional or process failures related to capacity and volume causing the erosion of the soil around or under them, and structural or material failures that cause culverts to fail due to collapse or corrosion of the materials from which they are made.[8] If the failure is sudden and catastrophic, it can result in injury or loss of life. Sudden road collapses are often at poorly designed and engineered culvert crossing sites. Water passing through undersized culverts will scour away the surrounding soil over time. This can cause a sudden failure during medium-sized rain events. There are more than 5,000,000 culverts currently in use in the United States alone. Continued inspection, maintenance, and replacement of these structures is crucial for infrastructure and safety. Accidents due to culvert failure can also occur if a culvert has not been adequately sized and a flood event overwhelms the culvert, or disrupts the road or railway above it. Ongoing culvert function without failure depends on proper design and engineering considerations being given to load and water capacities, surrounding soil analysis, backfill and bedding compaction, and erosion protection. Improperly designed backfill support around aluminum or plastic culverts can result in material collapse or failure from inadequate load support.[9][10] Soil and sand carried through a culvert can wear away the galvanizing of a steel culvert, allowing it to corrode and eventually collapse, disrupting the road or railway above it. This happened at a culvert near Gosford, New South Wales in 2007. Throughout history, engineers and construction companies have struggled with weak soils and all the challenges that come with building on them. Erosion and loose foundational soil made for uncertain construction projects. So, geotextile is used in the embankment.

Geotextile

Modern drainage systems incorporate geotextile filters that retain and prevent fine grains of soil from passing into and clogging the drain. Geotextiles are synthetic textile fabrics specially manufactured for civil and environmental engineering applications. Geotextiles are designed to retain fine soil particles while allowing water to pass through. In a typical drainage system they would be laid along a trench which would then be filled with coarse granular material: gravel, sea shells, stone or rock. The geotextile is then folded over the top of the stone and the trench is then covered by soil. Groundwater seeps through the geotextile and flows within the stone to an outfall. In highgroundwater conditions a perforated plastic (PVC or PE) pipe is laid along the base of the drain to increase the volume of water transported in the drain. Alternatively, prefabricated plastic drainage systems made of HDPE called SmartDitch, often incorporating geotextile, coco fiber or ragfilters can be considered. The use of these materials has become increasingly more common due to their ease of use which eliminates the need for transporting and laying stone drainage aggregate which is invariably more expensive than a synthetic drain and concrete liners. Over the past 30 years geotextile and PVC filters have become the most commonly used soil filter media. They are cheap to produce and easy to lay, with factory controlled properties that ensure long term filtration performance even in fine silty soil conditions.

2.MODELING

Finite element model

Finite element method is considered to be the best tool for analyzing the structures recently many software's uses this method for analyzing and designing, such as ABACUS, ADINA, ANSA, COSMOL, LS-DYNA, NASTRAN, SAP2000, ANSYS etc. The most popular and the easiest to learn is ANSYS software. This is an engineering simulation software (computer aided engineering) developer that is headquartered south of Pittsburgh in the Southpoint business park in Cecil Township, Pennsylvania, United States.Its widely used especially for the industrial works.

Modeling in ansys

The cross section of road embankment used in this study of 9 m crest width and 1:2 side slopes. The depth of the soft foundation soil is 10m finite element discretization of the problem. Due to symmetry along the centre line only half of the geometry was simulated.

Element type

- **Solid 45 -** Here, it is used for soil and geotextile. Solid 45 is used for the 3-D modeling of solid structures.
- **Solid 65 -** Here, it is used for concrete. Solid65 is used for the 3-D modeling of solids with or without reinforcing bars (rebar).
- **Beam 188 -** Here it is used for reinforcement. Beam188 is suitable for analyzing slender to moderately stubby/thick beam structures.
- **For node to surface - Conta175 -** Conta175 may be used to represent contact and sliding between two surfaces(or between a node and a surface or between a line and a surface) in 2-D or 3-D.

Modeling

The cross section of road embankment used in this study of 9 m crest width and 1:2 side slopes. The depth of the soft foundation soil is 10m. Due to symmetry along the center line only half of the geometry was simulate.

Table 1 Material Properties Of Concrete And Geotextile

Material properties	Concrete	Geotextile
Modulus of elasticity(Ec)(Pascals)	2.23×10^{10}	1.772×10^{9}
Density (kg/m^3)	2400	1026
Poisons ratio	0.15	0.3656
Yield stress(Pascals)	3×10^{7}	3.98×10^{7}
Tangent modulus(pascals)	1.071×10^{12}	1.772×10^{7}

Table 2 Properties Of Soil

Material	Embankment soil(fill	Foundation soil

	materials)	
E(Pa)	50 x 10^6	20 x 10^6
Poisons ratio(v)	0.15	0.2
Friction angle (degree)	35	25
Cohesion (Pa)	3 x 10^3	5.7 x 10^3
Density (kg/m^3)	2100	1500
Diltency angle (degree)	0	0

2.4.1 Circular culvert with geotextile

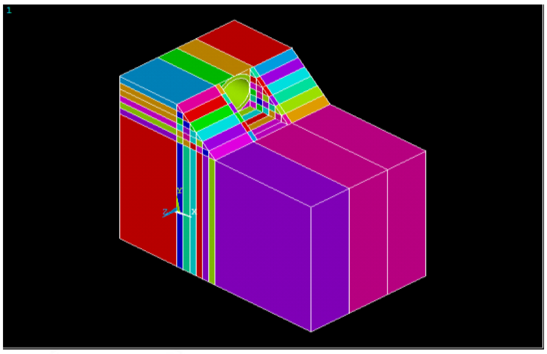

Fig 1 Circular Culvert Model

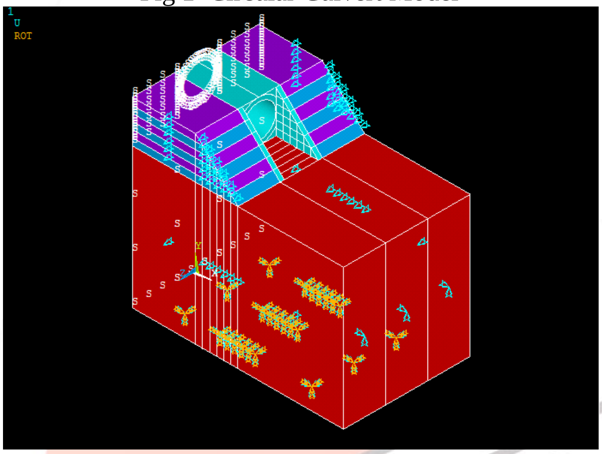

Fig 2 Circular Culvert Meshed Diagram With Constraints

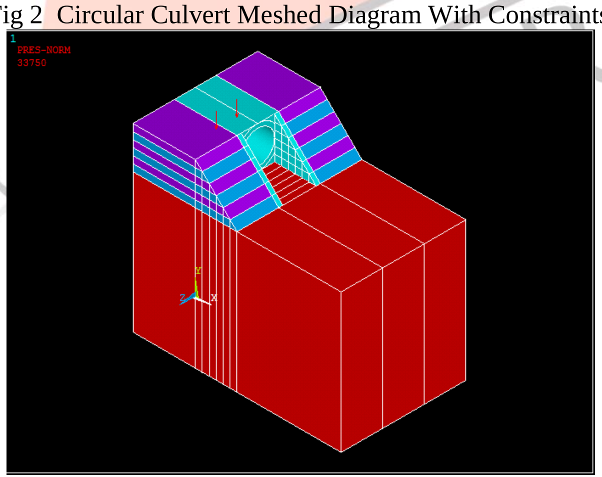

Fig 3 .Loading Diagram

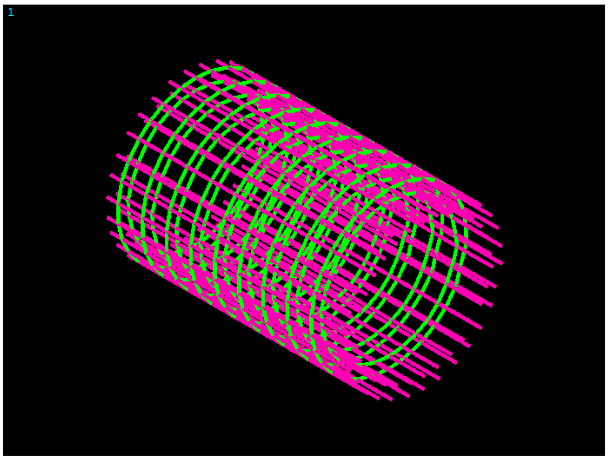

Fig 4 Main Bars And Stirrups Inside Circular Culvert

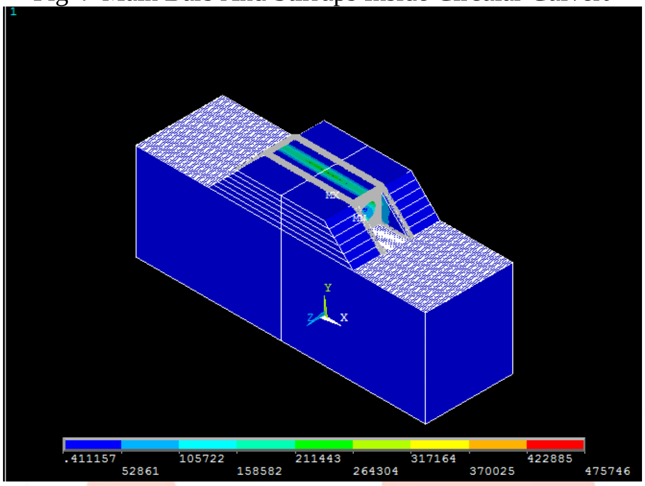

Fig 5 Von mises stress

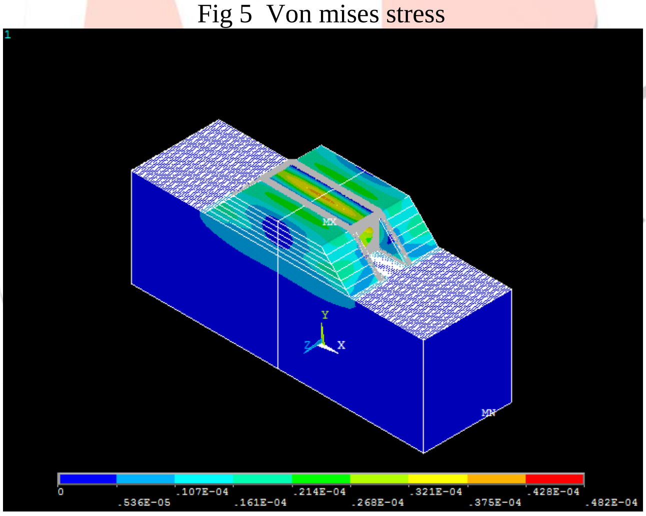

Fig 6 Displacement

2.4.2 Circular culvert without geotextile

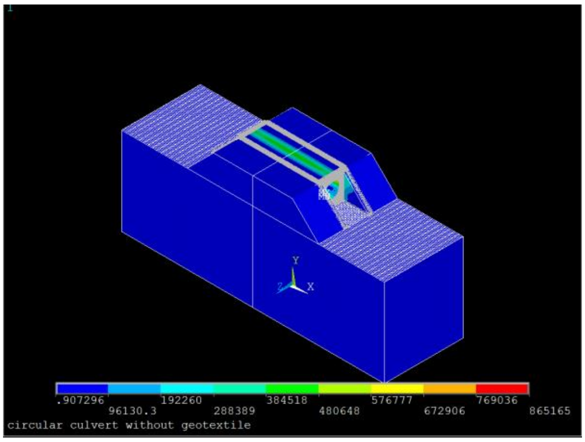

Fig 7 Von mises stress

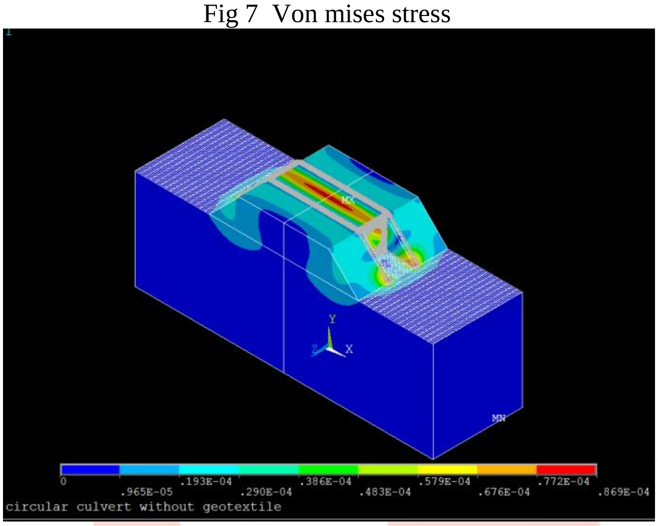

Fig 8 Displacement

CONCLUSION

Culvert function without failure depends on proper design and engineering considerations being given to load and water capacities, surrounding soil analysis, backfill and bedding compaction, and erosion protection. So geotextile is used in the embankment. Result of analysis, indicate that one of the primary function of geotextile was to reduce the horizontal displacement significantly. Also it is observed from the obtained result that stress and displacement for circular culvert constructed across with geotextile embankment is less than stress and displacement for circular culvert across without geotextile embankment.

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