Analysis of Road RC Tunnel with Change in Seismic Severity

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Abstract— Trails are the most important structures used for various construction such as roads, railways, for the purpose of protection and plumbing etc. Roads are very useful ways to cross physical barriers such as mountains or snow-capped areas. Earthquakes are one of the most deadly natural disasters we have ever experienced. The quake was widely reported as a major cause of landslides, landslides, landslides, landslides, and landslides. An earthquake analysis is the basis for structural analysis and the calculation of a structural response to earthquakes. Providing strength, stability and inclination which are the main objectives of seismic analysis. The tunnel design process is in this paper. The design is based on the natural and seismic forces. Steps are investigated and site construction is introduced in the event of an earthquake. In this paper the study is conducted in a tunnel in different earthquake zones with the same input parameters. And comparisons are made between the channels of different areas with different output parameters. And its severity has been tested.

Keywords: Road, RC Tunnel, Seismic Severity

I. INTRODUCTION

A tunnel is an underground way to secure barriers without disturbing the heavy ground above it, transporting goods, passengers, sewage, water, etc. The texture of the works may differ from the past to the present. But we know that earthquakes are one of the most destructive natural disasters. During an earthquake The waves of an earthquake cause earthquakes so we must consider the strength of the earthquake while designing the tunnel. In this we will learn about the impact of the tunnel on the action of earthquakes using various methods of analyzing earthquakes

II. SEISMIC ANALYSIS

Seismic analysis is part of a building project that includes earthquake engineering or building inspections and relocation in areas where earthquakes are prevalent.

A study of the inelastic behavior of the structure offline analysis is required. The development of a logical approach to the construction of new earthquakes using new knowledge of the movement of the earth and the knowledge of engineering, is nevertheless flexible enough to allow for the introduction of new technologies as they are now available. This is focused on major research and development efforts around the world. In most cases offline analysis is used.

A. Seismic Coefficient Method

The spherical balance system is one of the most stable processes for seismic construction. Horizontal and / or vertical forces, calculated as the products of the seismic coefficients KH, KV and the weight of the frames are applied to the frames.

The stability and twisting of the structures, as well as the pressure and weight of each structural element are assessed at horizontal and or vertical angles over a direct load due to the weight of the structures.

The seismic coefficients of KH and KV are determined by looking at the level of structural significance and seismic activity in the region. Typically, the corresponding earthquake coefficient KH is 0.2 - 0.3 for road and rail bridges, about 0.15 dams, 0.15 - 0.25 for ports and harbors and 0.6 for nuclear power plant structures.

The force of inertia F acting on a building during an earthquake is expressed in the following formula as a product of the total mass of structure M and acceleration α.

$$F = M \cdot \alpha \qquad (1.1)$$

Therefore, the seismic coefficient can be recognized as a ratio of the acceleration of structures to the gravity acceleration.

III. LOADS ON TUNNEL

The Various types of load such as self-weight, Earth pressure, water pressure, uplift pressure, Vehicular live load, overlying pressure and seismic force are taken for analysis of underground structure. The above loads are taken from IRC 6-2000.

A. Self-Weight

The resilience of the structure is very important because it has a great influence on soil erosion and controls the force of inertia. Once the basic size is known, your weight can be calculated for use in building construction and residential analysis. The weight of the ventilation equipment and other M&E plants is generally not included in the permanent load as it should be removed and replaced as part of the repair state. This survival varies in different stages due to changes in concrete strength. It is assumed that here the dry concrete is concrete.

B. Overlying Pressure

It is the pressure of the earth above the slab of the tunnel element which is acting in downward direction. The depth for this is considered as 2.5 m. The earth above the tunnel element creates a huge amount of pressure on the top slab of the element. This earth pressure can be calculated as

$$\text{Earth Pressure above the top slab} = h \times \gamma d \qquad (1.2)$$

Where

1) h=Height of earth above the top of tunnel
2) γd = Dry density of earth

- The most important potential loads acting on underground structures are earth/rock pressures.
- It may be generally stated, that the dimensioning of tunnel sections must be effected either against the overburden weight (geostatic pressure) or against loosening pressure (i.e. the weight of the loosened zone, called also protective or Trompeter's zone).

– Also its theoretical estimation is more involved than that of the roof load, since its magnitude is even more affected by the extent of deformations of the section, so that its value depends increasingly on the strength of lateral support besides the properties of the rock and dimensions of the cavity.

C. *Live Load*

As the tunnel is design as a traffic tunnel so the vehicular load is considered as live load

1) *Vehicular load (traffic load)*

Similar to transient vertical loads, the localized loads due to vehicles will need to be considered at the middle slab. The magnitude of the loads to apply will be as per IRC:6-2010. According to IRC:6-2010, the tunnel element is classified for IRC Class 70R loading and Class A loading case under clause 20.1.1. For both cases, analysis is carried out and results are obtained.

2) *Case I: 70R loading*

The design live load consists of standard wheeled vehicles as given in IRC. For each standard vehicle all the axles of a unit of vehicles shall be considered as acting simultaneously in a position causing maximum stresses.

3) *Case II: Class A loading*

Loading and analysis for this type of loading is 95.96 kN/m^2 ground contact area and wheel loads are according to clause 204.1

D. *Backfill Pressure*

The backlash provided over the sides of the tunnel section creates pressure on it. This reciprocating pressure is small in the upper sheath and the upper in the lower slide i.e. it varies in the trapezoidal shape. Properly integrated backlash material puts pressure on the side walls. The ground pressure equilibrium (K0) is 0.5 based on the resting state.

E. *Temperature Stresses*

Elements of concrete-centered tunnels are usually large members with a large lag of heat. Combined with a soil-blocking heat-retaining environment that maintains a constant temperature, the gradient temperature across the size of the members can be measured. However, these responsibilities will depend on local climate and seasonal changes. Since the proposed site does not have a separate impact of temperature changes these loads are smaller.

IV. NORMAL DESIGN CONCEPT

Normal design of tunnel for gravity loading is carried out and the design of RCC tunnel for gravity loading is presented.

A. *Loading Criteria*

Maximum Design Earthquake (MDE)

The performance goals of the MDE (i.e. Public safety), the recommended seismic loading combinations using the load factor design method are as follows:

$$U = D + L + E1 + E2 + EQ \quad (1.3)$$

Where,

U = required structural strength capacity,

D = effects due to dead loads of structural components.

L = effects due to live loads.,

E1 = effects due to vertical loads of earth.

E2 = effects due to horizontal loads of earth.

EQ = effects due to design earthquake (MDE)

B. *Seismic Coefficient Method*

The seismic coefficient method is used for the analysis of tunnel.

The seismic force to be resisted by bridge component shall be competed as follows

$$F = Ah\ W \quad (1.4)$$

Where

F = Horizontal seismic force to be resisted

W = Weight of mass under consideration ignoring reduction due to buoyancy or uplift

Ah = Design horizontal seismic coefficient as

Horizontal Seismic Coefficient Ah- The design horizontal seismic coefficient, Ah shall be determined from following expression IS Used for calculation the design horizontal seismic coefficient.

$$Ah = (Sa/g \times Z/2 \times I/R) \quad (1.5)$$

Provided that for any structure with T< 0.1 sec, the value of Ah will not be taken less than Z/2 whatever be the value of I/R.

Where,

Z = Zone factor

I = Importance factor Refer Table No 2 Of IS 1893 Part III

R = Response reduction factor Refer Table No 3 IS 1893 Part III

Sa/g = Average Acceleration coefficient for rock or soil sites.

Seismic zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Zone Factor	0.10	0.16	0.24	0.36

Table 1: Zone factor (IS 1893-2002)

Material	Dry Density KN/m^3	Safe bearing capacity KN/m^3
Water	9.81	---
Murrum	18	200
Backfill	18	200

Table 2: Material Densities

Type of soil	Avg. Acceleration Coefficient	Coefficient Value
For Rocky or hard soil sites.	Sa/g	1+15T, 0.00<T<0.10
		2.50, 0.10 < T < 0.40
		1.00/T 0.40 < T <4.00
For Medium Soil Sites	Sa/g	1+15T, 0.00<T<0.10
		2.50, 0.10 < T < 0.56
		1.36/T 0.55 < T <4.00
For Soft Soil Sites	Sa/g	1+15T, 0.00<T<0.10
		2.50, 0.10 < T < 0.67
		1.67/T 0.67 < T <4.00

Table 3. Average Acceleration Coefficient for Rock or Soil Sites (Is 1893-2002)

V. LOAD COMBINATIONS

When earthquake forces are combined with other forces such as dead load and live load, the load factor for plastic design of steel structures and partial safety factors for limit state design of reinforces concrete structures and prestressed concrete structures shall be considered. Load factors may be used as in IRC/IRS codes with the provision that when earthquake load (EL) and dead load (DL) are combined, load factor shall be minimum 1.5; and when seismic load is combined with all other loads, load factor shall be minimum 1.2. Partial safety factors for limit state design of reinforced concrete and pre-stressed concrete structures In the limit state design of reinforced and prestressed concrete structures, the following load combinations shall be accounted for

1) 1.5(DL+IL)
2) 1.2(DL+IL+EL)
3) 1.2(DL+IL-EL)
4) 1.5(DL+EL)
5) 1.5(DL-EL)
6) 0.9DL+1.5EL
7) 0.9DL-1.5EL

VI. Observation

To study the effect on the structural member of tunnel with the change in seismic severity the model and analysis is done for the three cases namely.

Case 1 – Analysis of Road RC Tunnel in seismic zone II
Case 2 – Analysis of Road RC Tunnel in seismic zone III
Case 3 – Analysis of Road RC Tunnel in seismic zone IV
Case 4 – Analysis of Road RC Tunnel in seismic zone V

The comparative observation tables are prepared for displacement of nodes and plate corner stresses and results are obtained from STADD PRO post processing mode after analysis and modeling of structures.

Plate no.	Zone	Max top N/mm^2	Max bottom N/mm^2	Mx N/mm^2	My N/mm^2	Mxy N/mm^2
25	Zone II	3.945	2.44	-1.158	-0.772	-0.492
	Zone III	7.404	6.2366	-1.017	-0.756	-0.547
	Zone IV	17.917	19.604	-1.173	-0.522	-0.317
	Zone V	41.128	40.2813	-0.932	-1.029	-0.725
26	Zone II	2.234	4.156	-0.839	-1.350	-0.692
	Zone III	5,777	7.871	-0.903	-1.440	0.431
	Zone IV	17.607	19.544	-0.931	-0.638	-0.566
	Zone V	40.153	41.257	-1.070	-1.050	0.692
24	Zone II	3.212	2.206	0.153	-0.758	0.017
	Zone III	6.208	5.106	0.127	-0.734	-0.015
	Zone IV	15.505	14.921	-0.385	0.087	-0.001
	Zone V	34.333	32.295	0.033	-1.311	0.014
23	Zone II	3.280	2.198	0.177	-0.886	-0.070
	Zone III	6.342	5.033	0.178	-1.014	-0.101
	Zone IV	14.845	15.589	0.120	-0.571	-0.075
	Zone V	34.367	32.265	0.041	-1.389	-0.041
21	Zone II	1.978	3.450	-0.567	-1.127	0.527
	Zone III	5.205	6.534	-0.533	-1.038	0.458
	Zone IV	17.058	16.239	-0.529	-1.023	0.739
	Zone V	135.196	36.217	-0.119	-0.429	-0.179
22	Zone II	1.955	3.481	-0.549	-0.161	-0.5277
	Zone III	5.146	6.594	-0.496	-1.112	-0.458
	Zone IV	13.7037	12.966	-0.403	-0.858	-0.591
	Zone V	35.178	36.232	-0.108	-0.450	0.179

Table 4: Plate corner stresses summary

			Vertical	Horiz-ontal	Result-ant	Rotation		
Zone	Location	X mm	Y mm	Z mm	Mm	rx	ry	Rz
Zone II	Load combina-tion 10	0.254	0.018	8.951	8.962	0.001	0.000	0.000
Zone III	Load combina-tion 10	0.262	0.021	9.110	9.112	0.012	0.000	0.000
Zone IV	Load combina-tion 10	0.277	0.026	11.510	11.520	0.019	0.000	0.000
Zone v	Load combina-tion 10	0.317	0.039	19.377	19.382	0.002	0.000	0.000

Table 4: Node Displacement Summary

VII. Conclusion

While the codal provision make it compulsary to make the structures earthquake resistive. It become equally importnant to study the effect of seismic forces for the structure which have soil pressure from all the sides like tunnel.

Since the equarthquake forces are transmitted through the ground waves, it becomes necessary to check the effect of ground forces on the structures.

To study the effect of seismic severity, the models of tunnel are created subjecting to the various seismic forces as shown in case II, III, IV, V. The material, grade, geometry are kept constant for all the forces. However, the seismic intensity is considered as per the codal provision given in IS 1893:2002.

The comparative analysis of nodal displacement as in table no. 7.1 shows that there is no major changes vertical forces development but the displacement in horizontal direction shows huge variation and it increases with increases in seismic severity. From the table no. 7.2 it is clear that all the four walls of tunnel are subjected to seismic stresses and comparasion shows that the stresse development are around two times more for zone III, six times more for zone IV, and fifteen to twenty times for zone V As that to zone II. The values gives alarming observation that signifies the compulsion utility of higher strength concrete, more ductile properties, and proper reinforcement provision so as to overcome the stresses developed due to earthquake forces.

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