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# Wildlife Navigation Alley Structure

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## Abstract

The rising cases of wildlife and human conflict due to their habitat been intervened by the large highway networks rushing vehicles into them has resulted in various catastrophic accidents, risking both the lives of animals and humans. By providing mitigating solutions to this problem risk to animals & human can be reduced to large extent. The aim of this chapter is to present a solution that serves both; wildlife's safety from road accidents along with the smooth passage of vehicles through a man-made alley structure. The man-made alley structure is setup in such a way that attract wildlife towards it & the path provided for the movement of animals is given in such a way that it not only adds up to the habitat of the animals but also gives a greater chance to the animals for colonisation, migration and interbreeding.

**Keywords**

Alley Structure, Geosynthetic Reinforced Soil, Wildlife

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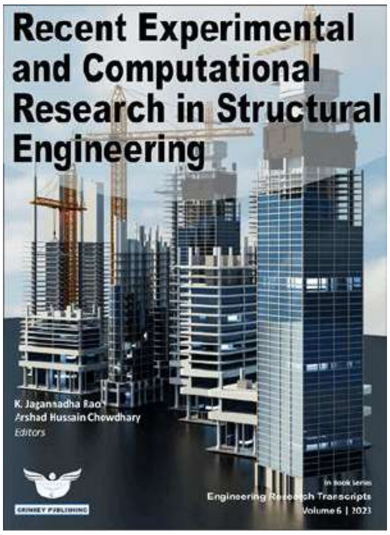


 

## 1. Introduction

Wildlife has been under constant threat of their habitat loss and even extinction in some cases resulting due to human activities along with climate changes. Major threats being trading of wildlife illegally, destruction of habitat, etc. and under the topic of wildlife destruction lies laying up of highways networks through forests area causing a serious disruption to the wildlife movement. The outcome being half of the world's forest area is gone, and what remains is being chopped down multiple times quicker than it can be replace, as a result the animals have no other option but to cross these highways acting as a division between their habitat patches [1]. This in turn leads to serious road conflicts threatening the lives of both the animals and the person driving the vehicle. Data from Wildlife Protection Society of India (WPSI), clearly mentions that this practice of setting up network of roads and railways in India is killing more animals day by day, showing our failure to handle the problem.

Such interventions has drawn major attention of authorities looking for mitigating solutions to this problem. The following project aims to deal with both; wildlife’s safety from road accidents along with the smooth passage of vehicles through a man-made alley structure.

Highlight of the structure is provision of a more ecologically sound and time saving method unlike conventional overpass construction method employing the provision of deep excavated foundations. The focus is on an effective method of building an overpass which could possibly be feasible in variety of regions having complex construction conditions. The alley structure would comprise of abutments of Geosynthetic Reinforced Soil (GRS) followed with prestressed girders placement in composition with in-situ concrete deck slab.

The wildlife alley is still in the process of being officially established as a legal tool for ecological conservation in India or, in fact, anywhere else in the world, but it could be a useful step toward conserving our constantly threatened wildlife settlements.

## 2. Methodology

### 2.1 Study Area

Below discussed structure idea is proposed for regions falling under Indo-Gangetic area i.e. the geographic conditions are quite compatible with the proposed idea where conventional structure settlement can be a problem. Also the concerned area is a home to various wildlife species in form of settlements namely Kanha-Pench corridor with NH-44 passing through it, Asola Bhatti Wildlife Sanctuary, the area being mentioned shelters one of the last surviving remnants of Delhi Ridge hill range, thus any such network establishment of roads will again effect those species adversely, Corbett- Rajaji Corridor having a 4.7 kilometre long road development cutting through the wildlife habitat which could be a threat to species like Asian elephant, Bengal Tiger, Striped Hyena, etc. being peacefully sheltered.

### 2.2 Design Procedure

The proposed methodology for designing of wildlife alley structure is shown in Fig. 1. It tells about the sequence of design the suggested structure.

The comprehensive structure design entails the integration of a Geosynthetic Reinforced Soil (GRS) abutment, T-girder, and deck slab, aligned with site conditions and load considerations to determine the structure's dimensions. The GRS abutment employs retaining wall stability principles, incorporating alternating compacted granular fill layers with geosynthetic reinforcement and outer hollow concrete blocks. Pre-stressed girder design follows a post-tensioning Freyssinet system, referencing IS 1343-2012, IS 875, IRC 6-2000 for dead and live loads, and IS 6006-2014 for uncoated stress-relieved strands. The slab deck, cast-in-situ with I-girders over a four-lane road, rests on the GRS abutment, forming the structural core. Development of natural vegetation involves layers (Geoguard membrane, drain cell, textile, soil, native vegetation) on the RCC slab to create a wildlife-friendly habitat. To ensure wildlife accessibility, the alley's strategic placement minimizes human interference and conflicts, supplemented by wildlife-discouraging fencing. Regular monitoring, facilitated by track pads and motion-sensitive cameras, coupled with a maintenance strategy, ensures the overpass's efficacy. This entails ongoing evaluation throughout planning, design, construction phases, with potential adjustments for improved performance, while the simplified design minimizes maintenance requirements when properly executed. The 2D design & drafting work was carried out using AutoCAD. IDEA StatiCa software was used for Structural Analysis.

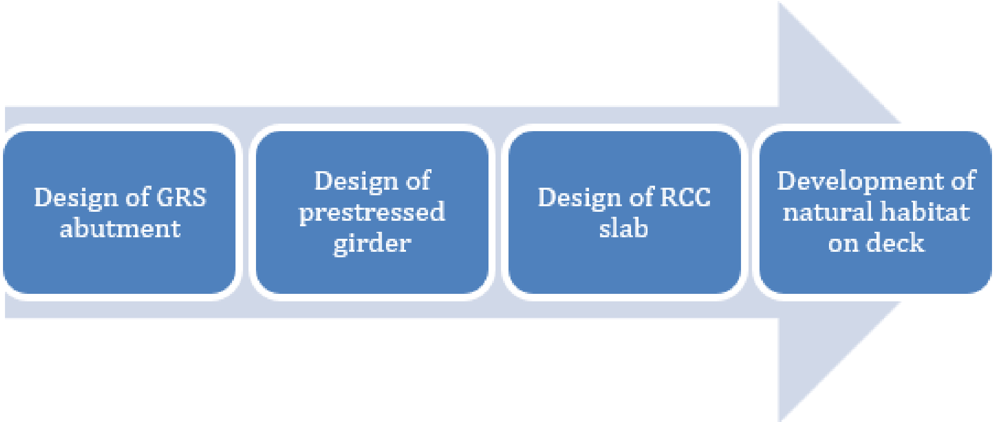


**Fig. 1.** Proposed Methodology for Wildlife alley construction

**2.3 Designing**

The Wildlife Alley structure is proposed between a 4 lane highway with a span of 22m as shown in Fig. 2 with width of deck = 7.5 m [2]. The main structural components to be designed are:

- Geosynthetic Reinforced Soil (GRS) Abutment
- Alley deck composed of prestressed girders with cast-in situ reinforced concrete slab having additional provisions for maintaining natural habitat to attract wildlife. While the loads on wildlife structures might be less compared to those on structures designed for human use, prestressed girders are used as they offer benefits in terms of durability, safety, and maintenance.

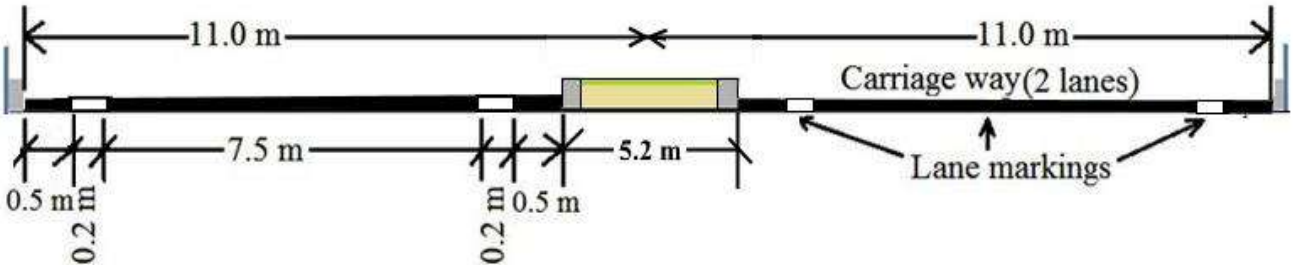


**Fig. 2.** Four lane highway's typical cross-section in India considered for design of Wildlife Alley Structure

**2.3.1. GRS Abutment**

GRS is a speedy, economical method of support that fuses the soil into the superstructure to create a joint less boundary between the overpass and the approach. In order to sustain the alley, which is built directly on the GRS abutment, the abutment alternates between layers of compacted fill and closely spaced geosynthetic reinforcement. Schematics of the proposed abutments are:

- Height of abutment (H): 7m
- Abutment length (L): 12.5m
- Alley/Base width ($B_b$): 5.5m

- Excavation depth for the reinforced soil foundation (RSF): $D_{RSF} = 1.40$m
- Reinforced soil foundation (RSF) width: $B_{RSF} = 6.9$m
- Concrete facing blocks dimensions: 400mm × 200mm × 200mm
- Max diameter of reinforced fill: 12.5mm

Tables 1 and 2 describe the loading as well as additional GRS abutment characteristics.

**Table 1**. Loading Calculation

| Loads | Depth | Density | Dead Load for unit width (kN/m) |
|---|---|---|---|
| Net DL load above slab | NA | NA | 65.497 |
| Dead Load of slab | 0.25 m | 25 kN/m$^3$ | 6.25 |
| Net Dead load | NA | NA | 71.747 |
| Factored Dead load (1.5xDL) | NA | NA | 107.620 |
| Net Live load | NA | 5.6 kN/m$^2$ | 5.6 |
| Factored Live load (1.5xLL) | NA | NA | 8.4 |

**Table 2.** Parameters for GRS Abutment

| Property | Equation | Measurement |
|---|---|---|
| Alley DL ($q_{DL}$) | $DL_{slab} + DL_{beam}$ [8]<br>= 6.25 + (4×8.625) | 40.75 kN/m |
| Alley and Pathway LL ($q_{LL}$ ) | Calculated & shown in Table 1 | 5.6 kN/m |
| Pathway DL ($q_p$) | Calculated & shown in Table 1 | 65.497 kN/m |
| Weight of GRS abutment (W) | $W = B_b H \gamma_r$ [8]<br>= 5.5×7×16 | 616 kN/m |
| Weight of RSF ($W_{RSF}$) | $W_{RSF} = B_{RSF} D_{RSF} \gamma_r$ [8]<br>= 6.9×1.4×18 | 173.88 kN/m |
| Weight of facing blocks ($W_{face}$) 20kg each | $W_{face} = N \frac{W_{block}}{length} = \frac{7}{0.2} \times \frac{0.2}{0.4}$[8] | 17.5 kN/m |
| Lateral load of retained backfill ($F_b$) | $F_b = \frac{1}{2}\gamma_b H^2 K_{ab}$[8]<br>$= \frac{1}{2} \times 18 \times 7^2 \times 0.28$ | 124.80 N/m |

### 2.3.2 Stability Analysis

#### 2.3.2.1 Sliding

Lateral forces produced by Retained backfill, slab base, and the surcharge are the driving force on the GRS abutment. The overall resisting weight (WR) comprises the girder weight plus GRS weight plus base weight over the GRS abutment. It is computed to ensure that the safety factor against direct sliding is always larger than 1.5. Upon calculation:

$$FOS_{slide} = \frac{R_n}{F_n} \Rightarrow 3.4 > 1.5 \text{ i.e. OK [8]}$$

#### 2.3.2.2 Bearing Capacity

Around the center of the base of the RSF moments are calculated. The base dead loads, lateral force due to the retained backfill and the live loads are the driving moments. The resisting moment include vertical force due to the alley and live loads and base dead loads. It is computed to ensure that the safety factor against bearing capacity failure is always larger than 2.5. Upon calculation:

$$\text{FOS}_{\text{bearing}} = \frac{q_n}{\sigma_{V,base}} \Rightarrow 3.6 > 2.5 \text{ i.e. OK [8]}$$

Final schematics of proposed GRS abutment are shown in Fig. 3.

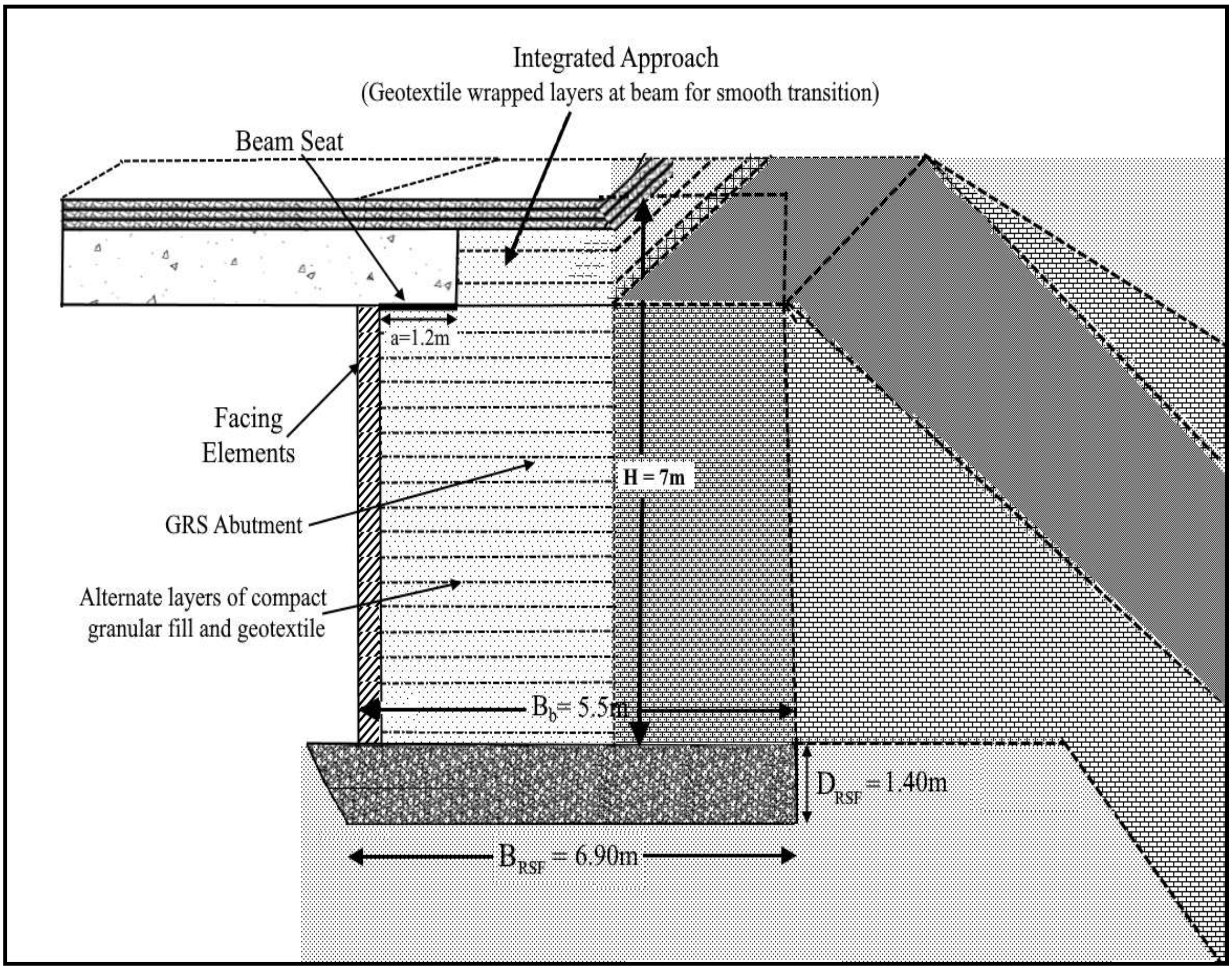


**Fig. 3.** GRS Abutments along with Dimensions

### 2.3.3 Alley Deck & Girder Configuration

- Width of deck = 7.5m
- For prestressed concrete girders, adopt M-45 (1: 0.8: 2.5) grade concrete
- For cast-in-situ slab, adopt M-25 (1: 1: 2) grade concrete
- High-tensile strands with a 15.2 mm diameter that comply with IS: 6006-1983 and Fe-415 HYSD bars

The main girders are precast see fig. 4 for its cross-section while deck slab is cast in-situ see fig. 5 for its cross section.

The alley deck is with following configuration:

- Four main girders are provided at interval of 2 m.
- Overall depth of girder (D) = 1100 mm
- Flange width ($b_f$) = 450 mm
- Web width ($b_w$) = 200 mm
- Cross sectional area of girder (A) = 0.345 $m^2$
- Moment of inertia of girder (I) = 0.0454 $m^4$
- Section modulus ($Z_t = Z_b$) = 0.082 $m^3$ (adequate)

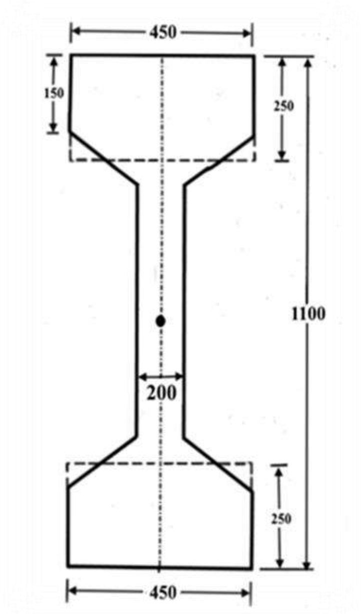


**Fig. 4.** Cross section of girder

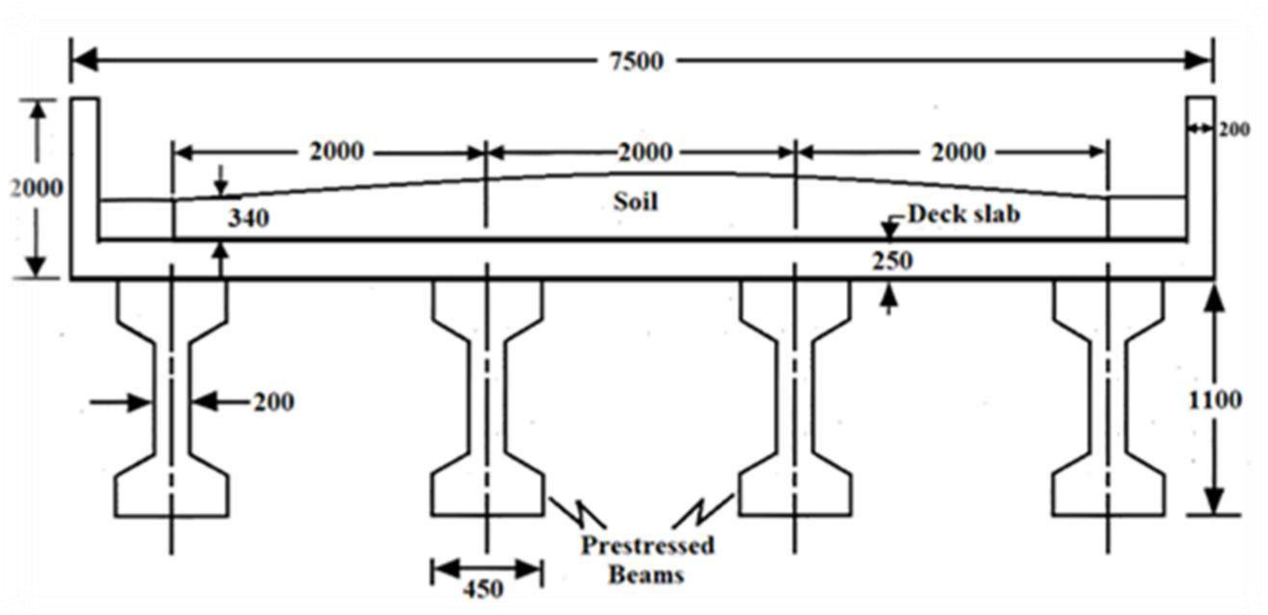


**Fig. 5.** Cross section of main alley deck

Other parameters of prestressed girders are shown in Table 3 while Fig. 6, 7, 8, and 9 show the concordant cable profile, its layout, and the details of the reinforcement, respectively. The slab detailing and its parameters are mentioned in Fig. 10 and Table 4 respectively. The final illustration of the designed Wildlife Navigation Alley Structure is shown in Fig. 11.

**Table 3.** Parameters for Prestressed Girder

| Parameter | Remark |
|---|---|
| Actual Pre-stressing Force | 3350 kN (3 cables (24Φ7) required) |
| Maximum possible eccentricity | 400 mm |
| Stresses (at mid span and support) | <20 N/mm$^2$ (The section passed the flexure and shear strength checks safely) |
| Supplementary reinforcements | 20 mm diameter bars are provided in the compression flange ($A_{st}$ = 0.15 % of gross cross sectional area) |
| End block | Solid end blocks, 450 mm by 1100 mm are provided for a length of 1m from each of the two end faces of the girder. |

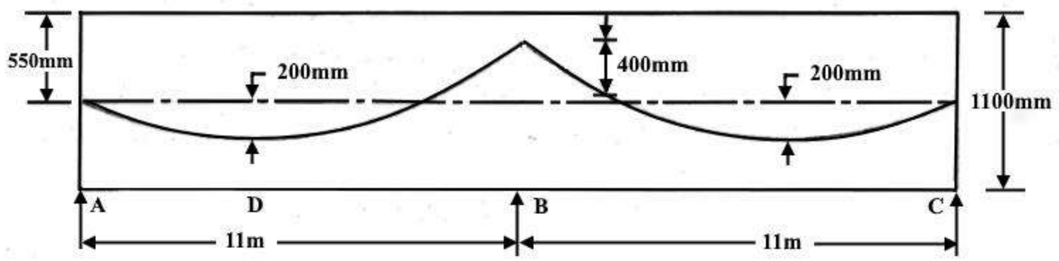


**Fig. 6.** Concordant cable profile

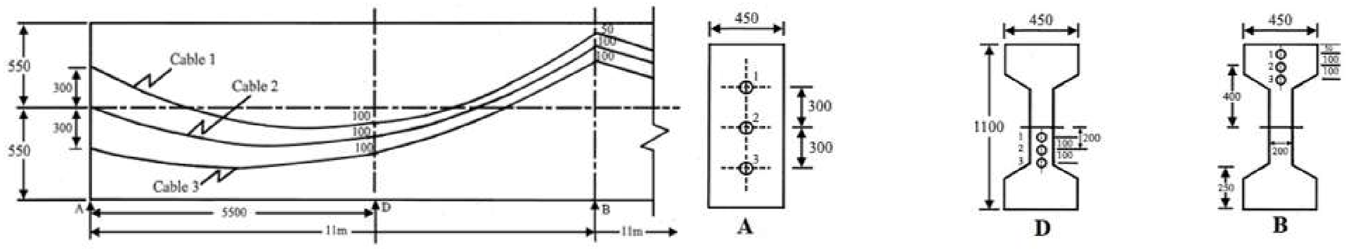


**Fig. 7.** Cable layout of main girder

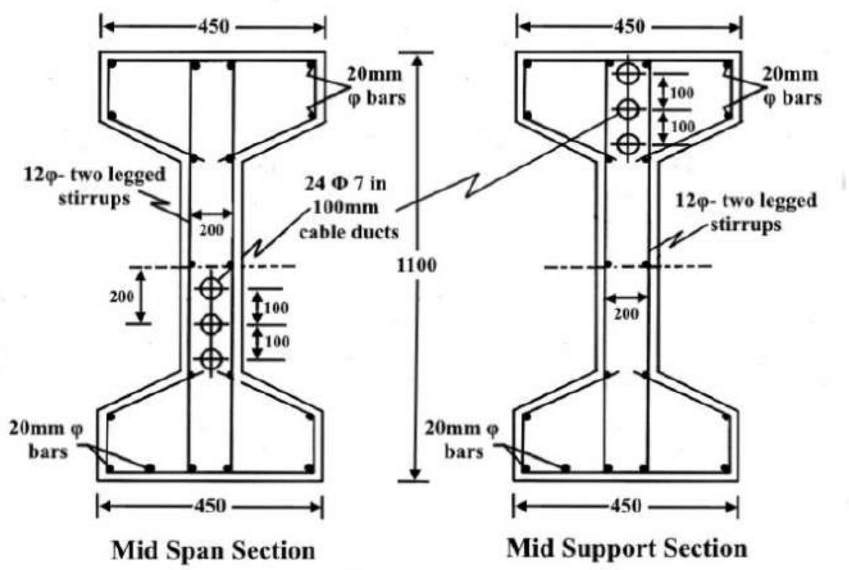


**Fig. 8.** Reinforcement details

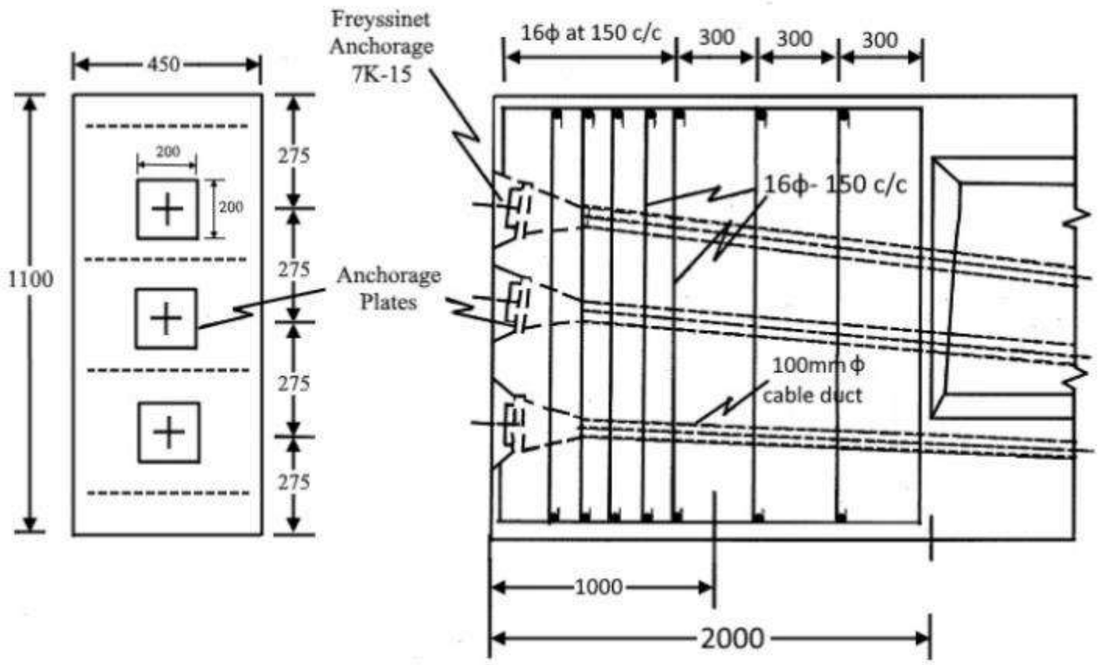


**Fig. 9.** Reinforcement in end blocks

**Table 4.** Parameters for RCC slab as per IS:456-2000

| Parameter | Remark |
|---|---|
| Depth | 250 mm with 30 mm effective cover |
| Main reinforcement | use 6-12mm bars @ 170mm c/c as main bars per metre bending of half bars is done at 300 mm from centre of girder |
| Distribution reinforcement | use 5-8mm bars @ 200mm c/c as distribution bars per metre |

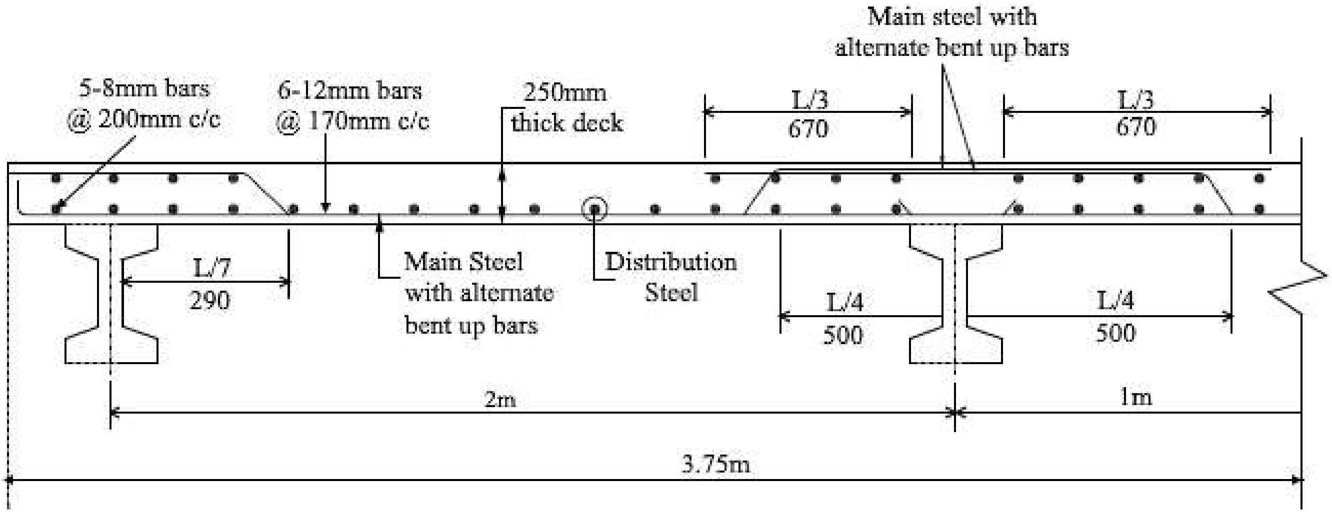


**Fig. 10.** Slab detailing

**Fig. 11.** Illustration of proposed Wildlife Navigation Alley Structure

## 3. Conclusion

The illustrative designing done here is as per suitability to be used in wildlife corridors of northern Indo-Gangetic region facing threats with growing road networks through them. The construction methods used being quite feasible and durable for instance installation of Pre-stressed girder in place of conventional beams provides a greater load carrying capacity in addition to being flexible of giving long span alley. The approach and exit to the alley structure on either side is kept such that it is convenient for animals to follow the path. Suitable barriers along the road ensure that the animals are deviated towards the alley structure for crossing. If this concept is put into action, it would commonly function as habitats with flora, which would facilitate movement while posing a lower danger of predation for species than open fields.

## 4. Future Scope

These studies done on conventionally developed wildlife navigating structures present positive results observed post construction. In terms of application in other sites across India, it can prove vital to curb man-wild conflict problems in India especially those concerned with Corbett- Rajaji Corridor involving 4.7-kilometre-long road development penetrating through the wildlife habitat, Sigur Elephant Corridor, Nilgiris involving a tussle over stretches of land embarked by the elephant movement and Kanha- Pench Corridor with NH-44 passing through it. Such intermediating solution can prove vital in solving these disputes of national interest with sustainable approach.

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