

**Restoration of Corridors to Facilitate the
Movement of Wild
Asian Elephants in Rajaji-Corbett
Elephant Range, INDIA**



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OBJECTIVE

India has the largest number of Wild Asian Elephants (19,000 to 29,000) and has a discontinuous distribution in northern, eastern and southern ranges. North-Western Elephant Range is among the important elephant areas in India and Rajaji and Corbett National Parks along with Lansdowne Forest Division and Sonanadi Forest Division are the main important habitats in this range. Development of rail line, highways, irrigation and hydroelectric canals, industrial establishments, human settlements along the migration corridors have fragmented the area and adversely affected the migratory movements of the elephants. These corridors are however necessary to facilitate dispersal and the migration processes, which are critical to species persistence.

The report suggests the alternatives and modifications in the man-made (Civil Engineering) structures to facilitate the movement of Elephants, save this endangered species from extinction and avoid the animal-human conflict in the Rajaji - Corbett Elephant Range. Detailed project has been formulated on the basis of elephant's behaviour towards the different existing civil engineering structures in and around the habitat for the construction of the new passages and modification/restoration of the existing structure at different locations. The estimated project will cost approximately 4.5 million U S Dollar.

It is expected that the proposals suggested in the report shall be able to restore the lost continuity in the movement of elephants in the Rajaji - Corbett Elephant Range, India to a great extent.

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1.0 INTRODUCTION

Habitat fragmentation is a problem faced by many species due to expansions in urban settlements and infrastructure. It has destroyed and fragmented the habitats of animals, and their migration between these fragmented areas has been hampered. As a result, many species are threatened in their existence and some are facing extinction.

One of the species facing these problems is the Asian elephant, as they require large areas of natural range than any other mammal species in tropical Asia, and therefore are one of the main animals to suffer the consequences of developmental activities. Their numbers are reduced to around 35,000 to 50,000 in the wild. The present distribution of the Asian elephant covers only a fraction of its former extensive range, and includes 13 countries, stretching from the Indian subcontinent in the west to Indochina in the east. They inhabit a land area of about 444,000 km², out of which only about 130,000 km² (30%) has been declared as protected area. Elephant population in Asia is small in size and highly fragmented, with fewer than 10 populations comprising more than 1000 individuals in a contiguous area (Kemf & Santiapillai, 2000).

species all over the world due to developmental activities. It is hampered, and as a result, some are even facing (local) extinction.

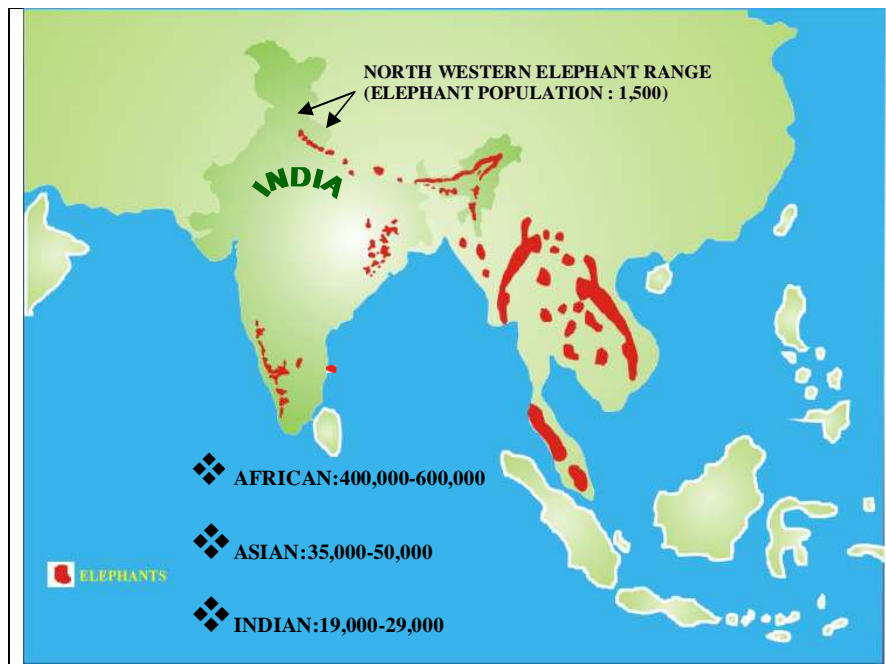


Fig.1-Present Geographic Distribution of Asian Elephants

India has the largest number of Asian elephants in the wild (19,000 to 29,000). The population of Asian elephants in India nowadays has a discontinuous distribution in northern, eastern, and southern ranges. They are largely restricted to the foothill areas because their natural habitat in the fertile river valleys has been taken over by humans for agricultural, industrial, and other purposes. Keeping this in view, the Government of India enacted a Wildlife Protection Act in 1972 (Schedule-I) and has declared the elephant as an **Endangered** species by putting it in the first of the six schedules of animals & plants. Simultaneously, in 1975, this flagship species is classified as **Endangered** and listed in

Appendix I of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES).

In the past, the elephants used to migrate freely in search of water and fodder from river Yamuna to river Brahmaputra covering nearly 1300km. Mostly the elephant's habitats are near the perennial rivers and many civil engineering structures are also constructed on the perennial rivers to draw water for irrigation and generating power. Many civil engineering structures, such as rail lines, highways, canals, etc. constructed in the habitats and migration corridors, have adversely effected the movement of elephants and fragmented long migratory routes in isolated zones. According to the 2005 census of Wild Asian Elephants, there are about 1510 elephants between river Yamuna and Indo-Nepal border in the northern region of state of Uttaranchal, which extend over a length of 400km and fragmented into several isolated zones. The major four fragmented zones, which harbours about 90 percent of the elephant population of the North Western Elephant Conservation Zone are between

- (i) river Yamuna and river Ganges
- (ii) river Ganges and river Kho
- (iii) river Kho and river Kosi and
- (iv) river Kosi and river Sharda.

In these zones, the hilly torrents are not very steep, passes through the deep forest facilitating the movement of wild elephants, but various structures constructed on these hilly torrents cause hindrance in the movement of elephants.

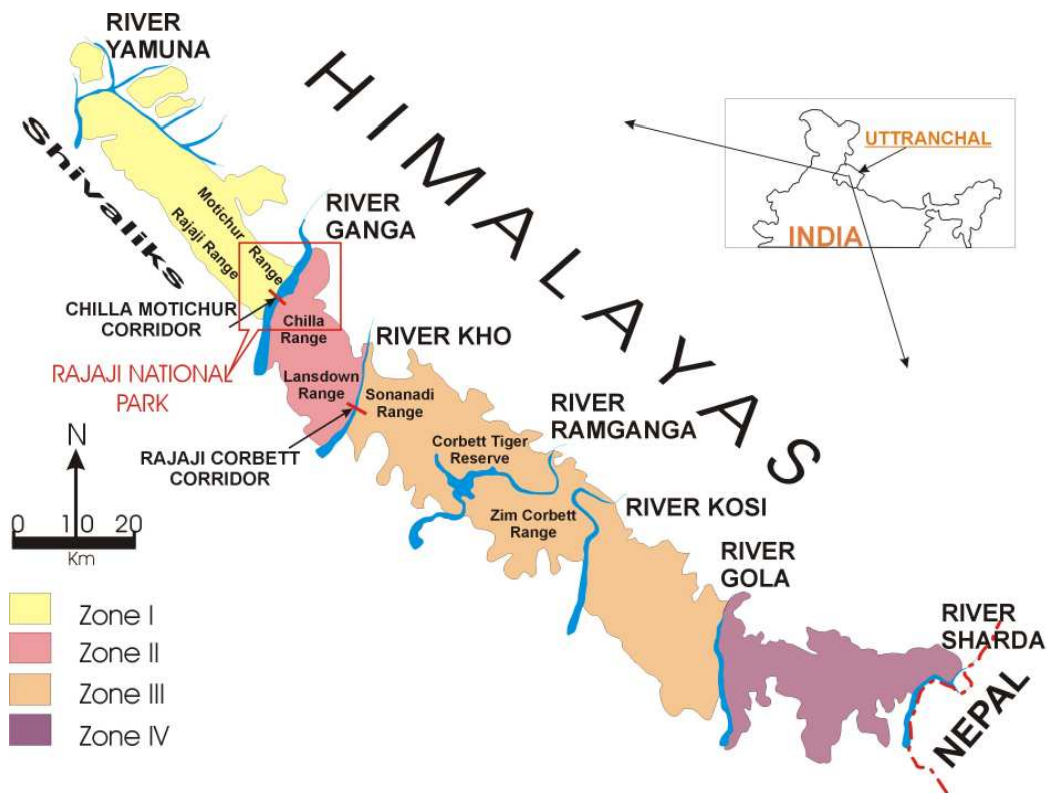


Fig.2-North Western Elephant Conservation Range

2.0 RAJAJI-CORBETTELEPHANTCONSERVATIONRANGE

Rajaji National Park and the Corbett National Park Division and Sonanadi Forest Division are the main elephants in this range. Development of railroads, hydropower channels, industrial and residential establishments near the river banks, human settlements along the migration corridors are mainly responsible for the fragmentation of the habitat of elephants (Fig. 3). Nowadays, the corridors between Rajaji National Park and Corbett National Park, necessary to facilitate species persistence, are no longer used by elephants due to various hurdles. Future developmental projects in the area without proper mitigation measures will worsen the problem.



Fig.3-Linear Developments in Rajaji National Park

2.1 Rajaji National Park

The Rajaji National Park is located in the foothills of Shivalik range and Garhwal Himalayas between $29^{\circ} 52'$ to $30^{\circ} 16'N$ and $77^{\circ} 52'$ to $78^{\circ} 22'E$ in Haridwar, Dehradun and Pauri districts of Uttaranchal. The altitude of the main portion of the park lies around 365m above M.S.L. The Ganges flows 24 km through the park dividing it into two unequal halves, with a core area of 820km^2 . The western portion occupies 571km^2 (right bank) and the eastern portion covers 249km^2 (left bank). The park has significant conservation values. It includes a large area of the fragile Shivalik ecosystem. The fauna and flora of this region are similar to that of the Himalayan and the Gangetic Plains. The Asian Elephant (*Elephas maximus*) is the most important flagship species found in the Park. The Rajaji National Park (820km^2) consists of mainly moist deciduous forests with riparian forests along the river. There are approximately 416 Asian elephants (79 males, 187 females and 150 calves) in this Park as per the 2005 census carried out by the park authorities. Other common herbivores living in the park are Sambar, Chital, Barking Deer, Goral, Nilgai, Common Langur and Rhesus Monkey. Omnivores present in the park include Sloth Bear, Wild Bear and Indian Palm

Civet and the carnivores present are Tiger, Leopard, Wild Dog, Jackal and Hyaena.

2.2 Corbett National Park

The Corbett National Park (521 km²) is the homeland of approximately 560 elephants (84 males, 274 females and 202 calves) as per 2005 census carried out by the project authorities and lies 110 km north east from river Ganges. Both national parks, together with the areas connecting them, form the North – Western elephant range (about 4000 km²), is homeland of 1510 Wild Asian Elephants.

2.3 Chilla-Motichur Corridor

The Chilla-Motichur corridor lies across the river Ganges and connects the eastern (249 km²) and western (571 km²) part of the Rajaji National Park. The corridor is approximately 3 km long and 1 km wide. This Corridor is formed by the *Motichur* torrent on the west bank and *Sonisot, Mundal* and *Ghasiramsot* torrent on the east bank joining the river Ganga. Mainly these torrents form the pathway for the elephants up to the river Ganga. On the west bank, the corridor is intersected by the Haridwar-Rishikesh/Dehradun road and rail line. The right bank of river Motichur is under intense human habitation whereas the left bank has an army camp. The forest patch on the left bank connecting river Ganga has been washed away due to floods.

The eastern side of corridor on the left bank of river Ganga is intersected with a wide by wide and deep channel of Chilla Hydropower Project. A road bridge has been constructed on the power channel at km 14.3 for routine inspection. As the bridge is located on the left bank of Sonisot torrent, so occasionally the elephant use this bridge to cross the canal for going to the river Ganga and other side of the park. The bridge is only 5.0 m wide and having 1.0 m high R.C.C perforated railing.

With the presence of traffic on the road and rail line round the clock, no forest connectivity up to the river Ganga on the right bank, intense human habitation around banks of river Motichur, and wide and deep channel of Chilla Hydropower Project without migration arrangements on the left bank of river Ganga, the elephant movement along the Chilla-Motichur Corridor in the Rajaji National Park has been completely stopped.

2.4 Rajaji-Corbett Corridor

The Rajaji-Corbett corridor lies near the eastern boundaries of Rajaji National Park, near *Kotdwar* town across the *Kho* River in the *Lansdowne* Forest Division and connects the elephant population of both the Rajaji National Park and the Corbett National Park. The entire width of the corridor in the flat ground/lowlands is under intense human habitation. Many times, the elephants try to cross the river *Kho* by going up hills on the right bank of river *Kho*, but due to the difficult topography of the area and presence of the *Kotdwar-Lansdowne* road, they are unable to cross over. The *Kotdwar-Lansdowne* road, constructed with steep edges, intersects the corridor and runs parallel to the River *Kho*. High walls have

also been built on inner side of the road to prevent landslides and these constructions, together with traffic, prevent elephants from crossing.

This corridor is also under threat due to intensive human dependency on this area for daily fuel and fodder requirements by members of local communities (Badola, 1998, Sunderraj *et al.*, 1995). Presently only bulls use this hilly corridor and the migration of elephant herds between the Rajaji National Park and the Corbett National Park has been completely stopped.

3.0 PSYCHOLOGY AND BEHAVIOUR OF ELEPHANTS

3.1 Migration

An elephant is a long distance migratory animal. Elephants devote their three fourth life in moving in search of water and fodder. In general, they stay in an area for a few days and migrate to other places. Elephants like to take bath daily in summers and that too in deep waters. It has been observed that during the warm weather, groups of elephants try to reach water resource in the noon or after noon. Since the availability of water and fodder changes seasonally in the park, the elephants migrate in the park to even shorter distances in search of water and fodder.

3.2 Psychology and Behavior

An elephant is a sensitive and intelligent animal and likes to move in free and quite environment. Whenever the herd finds any obstacle on the migratory or movement track, it tries to avoid the route and sometimes even adopt a longer path to fulfil their need. They generally move very cautiously in the group to protect the younger elephants. They normally move in a herd in a spread pattern but remain in visible range. Baby elephants generally stay under the mother and whenever they come across any steep ditch or obstacle, the mother lifts the baby elephant with her trunk. In general, there is an intense bond and love between the elder elephants and the younger ones. Sometimes, group clashes among the elephants also results in death.

3.3 Food Habits

The elephants consume 75-150 kg of food and 80 to 160 litre of water every day. Their food consists of mostly grass, tender shoots, twigs, barks, leaves and fruits.

4.0 PROBLEMS FACED BY WILD ASIAN ELEPHANTS IN AND AROUND RAJAJI NATIONAL PARK

In Rajaji National Park originally the total width of park (approximately 20 km) was touching the river boundaries on both banks of the river Ganges. Due to human expansions, the area of Rajaji National Park is very much fragmented besides, the construction of roads, railroads and canals has led to segregation of the parks. Presently on the left bank, only two patches (approximately 1.0 km long patch upstream of Pashulok barrage of Chilla hydropower project and 4-5 km long patch between the Chilla power house and Haridwar barrage) and on the right bank only one patch (approximately 0.2-0.3 km long patch upstream of

the confluence of Motichur torrent with river Ganges) of the forest are touching the river boundary.

4.1 Haridwar-Rishikesh/Dehradun Highway

On the West Bank (right bank) of the Ganges, a highway runs across the narrow Chilla-Motichur elephant corridor, dividing the park into two segments. Initially this was a forest road and the traffic was low. But over the years, this passage has become a virtual lifeline to the Uttaranchal state. It now experiences very heavy traffic, round the clock and soon this two-lane highway is going to be upgraded into a four-lane express highway connecting the state capital Dehradun to New Delhi. Many times the crossing elephants chase the moving traffic on the road and sometimes they stay on the road-stopping the whole traffic on the road.

4.2 Haridwar-Rishikesh/Dehradun Rail line

On the same right bank, a rail track runs 23 km in side the park, out of which 18 km is an accident-prone zone. This rail line runs parallel to highway (about 50-150 m apart) between Motichur and Raiwal towns—approximately in 2.0 km length. It has become a busy route with the introduction of several fast-moving trains, mostly between 5 p.m. and 11 p.m., just when elephants usually like to cross for going to the water source, particularly the river Ganges and Ganges. These are the only perennial sources of water in the area. The fastest moving trains, especially the trains running in the night are a major threat to the he elephants in this area. The park has lost 16 elephants in eleven major accidents between 1987 to 2000, besides other animals.

4.3 Chilla Power Channel

On the eastern side of the Ganges (left bank) two canals split the area. The northern one, a 14.3 km concrete lined canal (44.5 m wide and 9.1 m deep), is constructed as a part of a hydropower project. Before the construction of the canal, seven major torrents (dry riverbeds) were used by the elephants as a pathway for their daily movements to the river. Now the elephants have stopped using these movement paths due to the following reasons:

- ◆ the wide and deep canal forms a barrier which they cannot cross and
- ◆ the provisions made in the cross drainage structures are inadequate for crossing over by the elephants.

4.4 Eastern Ganga Canal

Another canal (on the same bank), more to the south has been constructed to provide the irrigation to the Bijnor and Moradabad districts in the state of Uttar Pradesh. Approximately 19 km length of Eastern Ganga Canal in head reach is situated within the elephant habitat. The canal is 26.0 m wide and 4.5 m deep and its side slopes are boulder pitched and lined with cement concrete tiles. Many cross drainage structures on the torrents have also been constructed which has badly affected the migration of elephants.

Due to the presence of rail road, road and the canal, elephants are unable to migrate inside the Rajaji National Park along river Ganges. As a result the population on the west bank of river Ganges, believed to be 311 elephants (2001 census) is now effectively cut off from the east bank herds in the Rajaji National Park. Besides, access to the legendary river Ganges, which the elephants used to visit daily for drinking, bathing and beating the heat in summer months has been severely hampered. Therefore the elephants look for alternative sources of water and food and as a result they enter human habitation and croplands, leading to human-elephant conflicts.

4.5 Kotdwar-Lansdowne/Pauri Road: Rajaji–Corbett Corridor

The Rajaji-Corbett corridor faces similar problems. The Kotdwar-Lansdowne road traverses the corridor and runs parallel to the river *Kho*. There is a heavy traffic on this road particularly during the daytime. This road is constructed with steep edges and high walls to prevent landslide. These constructions, together with the traffic, prevent elephants from crossing.

4.6 Recent Incident

During a rainy season in 2004, a male elephant migrated along the nallah and was stuck in the small forest patch between the Haridwar–Rishikesh road and right bank of river Ganges just upstream of Bhimgoda Barrage in Haridwar. Lot of efforts were made by the forest officials to stop the male elephant to cross the river Ganges to go to the forest area on the other bank, but the elephant refused to cross the river Ganges and ultimately, the elephant was tranquilized and carted to the forest. This example illustrates that the lone elephant was scared by the size and flow of river Ganges because the elephants seldom reach the river Ganges in the park due to various artificial obstacles in their migratory route. Although the swimming is an inherent property in the elephants. The authors are of the opinion that due to non availability of sufficient depth of water in torrents in the park, the elephants have lost the art of swimming and therefore the lone elephant was not prepared to swim to cross the river.

Due to the fragmentation of habitats, migratory routes of the elephants have been closed; there is an unequal distribution of sources of water and food plants on either side of various man made barriers in the park. The unequal natural resources may create an ecological imbalance in due course of time because

- ◆ the alternate water sources do not have the sufficient depth of water for elephants to swim.
- ◆ the alternate sources of water are generally located near the human settlements, polluted water may cause some deficiencies and diseases in the elephants.
- ◆ the mortality rate of elephant's in-group clashes have risen. It has been observed that the group clashes are due to assemblage of more number of elephant group near the available sources of food and water, when the water sources dry up in the upper reaches of the park.
- ◆ Due to the blockage of migration routes, the bulls are not able to join new herds so there are chances of inbreeding in place of cross breeding, which will ultimately result in genetic deficiency.

5.0 BEHAVIOUR OF ELEPHANTS AND THE REQUIREMENT FOR THE DESIGN OF PASSAGES

The attributes and their effects described in the preceding paragraphs have to be implemented to determine the exact requirements for a passage for the wild Asian elephants.

The elephant is a long distance migratory animal. The purpose of this migration is to get water, fodder and a mating partner. They normally move in herds in a spread pattern, but within visible range, often using torrents or natural depressions as their path of movement.

Elephants live in family groups. There is intense bonding and love between elder herd members and young calves. Trains passing through at high speeds often divide herds and this understandably causes elephants to feel that calves on the other side of the track are being threatened. This situation creates confusion in the herd and may lead to elephants running into the train, particularly in the night.

The elephant is a sensitive and intelligent animal and requires a free environment without any hindrance. If the herd is disturbed (for instance by traffic) or if it finds any obstacle on the movement track, it tries to avoid the area even at the cost of travelling long distances to fulfil the same objective elsewhere. They are not ready to accept any man-made structure with a roof because none exists in their natural environment. This can be illustrated by the barrels of the Duggada aqueduct on Chilla power channel (Fig. 4). The barrels are six in numbers and each 8.0m wide and 6.0m high and more than 100.0m long. The project was commissioned in 1982, but till today the herds have not accepted these barrels to move across. Only the Bulls are using these barrels for moving to the other side of Chilla power channel.

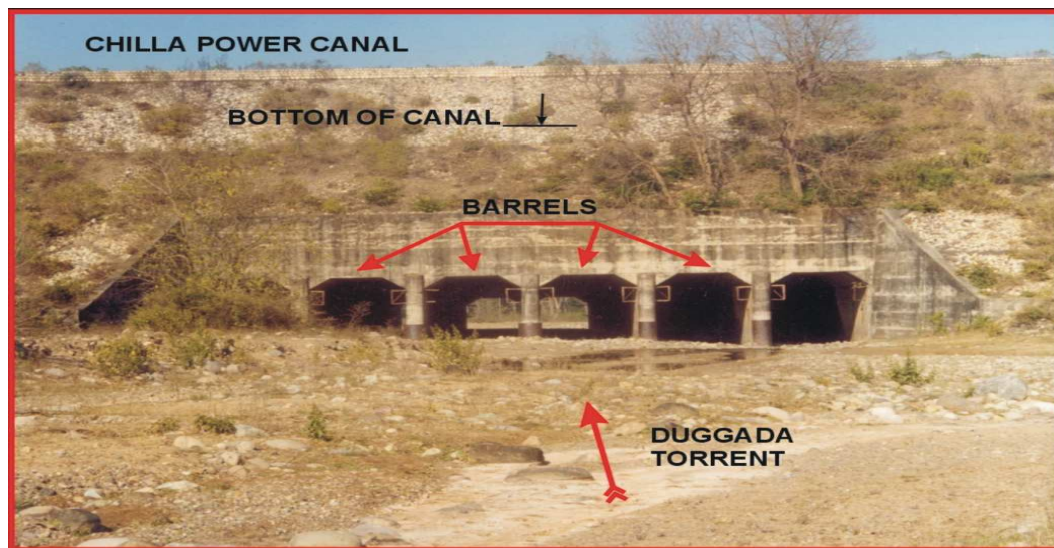


Fig.4-Dugadda Aqueduct on Chilla Power Channel

Two road bridges (5.0m wide) have also been built on Chilla Power Channel for crossing the channel. The volume of road traffic on this canal road is low in day

time and almost nil in the night. The first bridge Bhogpur and another near the Soni torrent. The bridges regularly for crossing the canal but the he torrent bridge occasionally in the night only. Since width of the passage is also a very important aspect designing bridges or passages. Due attention shall and acoustic disturbance to the elephants by the mo and designing the structures.

is situated near the village one bulle elephant use these rds are using the *Soni Sot* e the elephants live in herds, t to be considered while also be given to the visual ving traffic, while planning

6.0 SOLUTION: CONSTRUCTION OF ECO FRIENDLY STRUCTURES FOR ELEPHANTS

Re-establishing the corridors in Rajaji-Corbett National Parks is necessary for the survival of the elephants so that they can have access to the original source of water and other fodder requirements. It is the need of the day to plan the developmental activities in the Rajaji-Corbett area in such an eco friendly manner so that the big animals can adapt the mitigation structures for crossing over for water, fodder and genetic exchange. Due attention should also be paid to animal behaviour, economical and socio-political viability while planning civil engineering structures in the area. Some of the suggestions are given by the authors in the succeeding paragraphs:

ional Parks is necessary for the ess to the original source of of the day to plan the in such an eco friendly manner ructures for crossing over for hould also be paid to animal while planning civil engineering given by the authors in the

6.1 Construction of Elevated Highway

If the topography/landscape permits then the elevated highway (Fig. 5) with sufficient headroom and wide spans of bridge can prove to be a good solution for

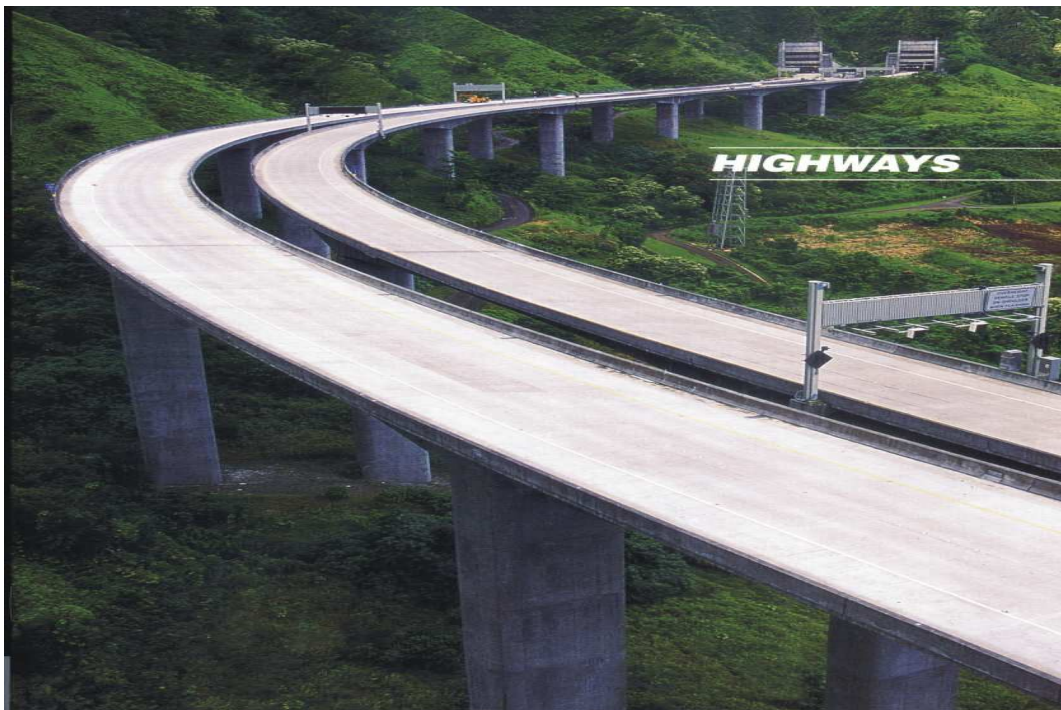


Fig.5-View of an Elevated Highway in U.S.A. in a Reserve Forest for the Safe Movement of the Animals

mitigation of elephants across the road. However, the elephants may get disturbed due to the sound of the moving traffic and glare of lights in the nights but the problems can be managed with the following provisions;

- speed restriction on the vehicles using the elevated highway
- complete ban on the blowing of horns of the vehicles using the elevated highway
- siderailing of the elevated highway bridges should be made sufficiently high so that the glare of the headlight of the vehicles should not fall on the movement track of the elephants.
- look of the structure should match to the surrounding landscape by using different colouring pattern on the outside of the structure.
- The edges of the concrete structure be rounded off instead of sharp corners.
- The speed of the vehicles using the elevated highway between 11.00 PM to 2.00 AM be restricted to 15-20 km/hr to reduce the disturbance. This time slot can help the elephants to cross to the other side of forest.

6.2 Construction of Eco-friendly Overpasses

The width of the overpass seems to be crucial for effectiveness, especially for larger wildlife, which do not use narrow bridges to cross over, particularly over railways or busy roads, where disturbance levels are high (Fig. 6). Research by Keller & Pfister (1997) indicates that the use of bridges by mammals increases when the width is 50 m or more.



Fig.6–Perspective view of the proposed combined overpass on rail line and road in Chilla–Motichur Corridor

The height of the overpass is another important aspect. The best way is to locate the passage on ground level so that the animals do not have to climb or descend in an unnatural manner. Under ground construction of highway in an area can solve the problem to a large extent. However, if it is not possible to

construct an under ground highway, then the shape shall be designed, keeping in view the natural surroundings, landscaping and gentle upward slope so that it can be accepted by the elephants for crossing over.

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Fig.7–ViewofProposedFencing

The passages should be built as sites close to a migration routes. It is important that the passage be guided with the help of fencing to reach the extreme points of the fencing be well connected with the endpoint, so that they do not cross over in the danger area.

bitat and along the established migration routes. It is also suggested that the animals reach the overpasses (Fig. 7) and the endpoint, so that they do not cross over in the danger area.

6.3 Eco-friendly Bridges on Channels

Eco-friendly bridges can prove to be a good alternative for crossing wide and deep irrigation and power channels by elephants, if their shape and appearance resembles to the surrounding environment. Existing bridges on the Chilla power channel are common to vehicular traffic as well as wildlife. The width of the bridge and the height of side railing has been found to be insufficient for the free movement of elephants to cross the channel. Due to the requirements of various wild animals for fixing the size, shape and appearance so that they can be accepted by the animals for crossing over. Some of the recommendations are:

native for crossing wide and their shape and appearance bridges on the Chilla power wildlife. The width of the bridge to be insufficient for the free movement of elephants to cross the channel. Due to the requirements of various wild animals for fixing the size, shape and appearance so that they can be accepted by the animals for crossing over. Some of the recommendations are:

- ◆ the width of the bridge be kept at least 15-25m

or movement of herd.

- ◆ the sidewall or railing be made blind up to a height of 2.75 m or blind up to 1.5 to 2.0 m with camouflaging up to a height 2.75 m with some locally available creepers (Fig. 7) to match the appearance of the wall to the surrounding forest so that the elephants are not visually disturbed by the turbulent water in the channel.

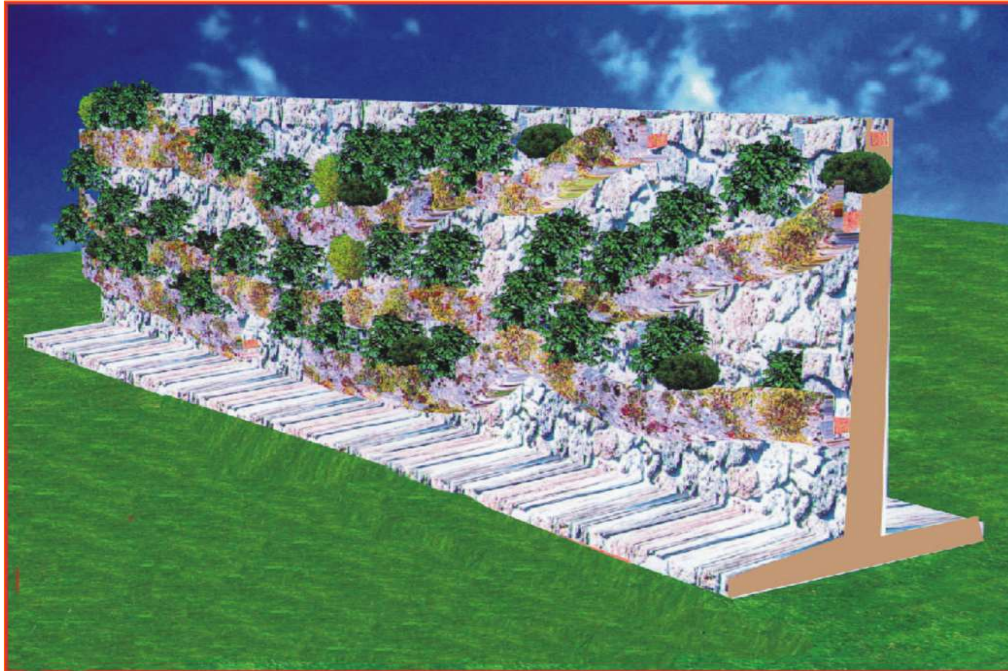


Fig.8–View of Camouflaged Side Railing of a Bridge

6.4 Water Tanks

Artificial water tanks are also good alternate for the elephants as an alternate source of water after the blockage of their access to the natural water sources. Four water tanks have been provided along the existing Chilla Power Channel and elephants can be seen daily at these tanks during hot days. On the basis of the experience of the existing tanks, following recommendations are made to enhance the use of artificial water tanks by elephants:

- ◆ Tank be made sufficiently large in size to accommodate big herd and be constructed quite away from the channel inspection road.
- ◆ Sufficient forest cushion between the canal inspection road and the tank be provided, so that elephants are not disturbed by the moving traffic on the road.
- ◆ Circulation of water be done by providing an outlet to maintain the water quality.
- ◆ Tanks be cleaned periodically, at least twice a year.

7.0 PROPOSALS TO FACILITATE MOVEMENT OF ELEPHANTS IN RAJAJI-CORBETT ELEPHANT RANGE

Based on the experience and research carried out on the wild Asian elephants, the following structures are proposed to be constructed along the corridor in the Rajaji-Corbett Elephant Range to facilitate movement of elephants:

7.1 Mitigation Structures for Rail line and Road between river Motichur and Raiwala town

The forest width between river Motichur and Raiwala town is bisected by the road and rail line simultaneously. Both impediments run parallel (50-100 m apart) along the full length. As the new state of Uttarakhand is in a developing stage, the rail and road traffic will increase in the coming years and therefore proper provision for the future developments should also be made in planning the size of the mitigation structures. The following two types of arrangement have been proposed to resolve the problem:

7.1.1 Construction of elevated highway bridge for the road only (Alternative-I)

A few planners/researchers have suggested that out of 2000 m long road reach between river Motichur and Raiwala town, an elevated highway bridge be constructed in 500-600 m length only to facilitate crossing of the elephants with suitable fencing in rest 1400 m (i.e. 2000-600) reach of the road for restricting the entry of elephants on the road and to guide towards the passage. It can be said that even if the elephant hesitates to cross over to the other side in the daytime, they will certainly cross during the night.

There is a railway and road bridge on river Motichur and level crossing of the rail line and road on the western end of the proposed elevated highway. The proposed elevated highway be planned in such a way that the requirement of road, rail line and the level crossings are also fulfilled. Construction of an overbridge, in place of existing level crossing on rail line and road, on the left bank of river Motichur and joining it with the east end of elevated highway shall be the most suitable, economical and viable solution from the elephant's migration point of view at the location. It will also reduce the disturbance level near the migration route of elephants as vehicles will not stop after the construction of overbridge.

However, the problem due to existing rail line running parallel to road will remain there and it is also to be mentioned that more than 20 elephants have already been killed by the moving trains in the same park on the same railway track. In future, number of trains on the track may increase and on more rail line parallel to the existing line may be constructed, which may create hurdles in coming years in the migration of elephants and the habitat on both side of the river Gangama may be **permanently fragmented**.

7.1.2 Construction of combined overpasses on the west side of river Ganges on Railroad and Highway (Alternative-II)

This route is an age old migratory route of elephants. Due to the topographical constraints, it is not possible to lower down the railroad and highways in the

underground tunnels and therefore it has been suggested that at least two number wide and flat combined overpasses on the railroad and highway be provided in the area with suitable fencing. It is necessary to provide the overpasses, as the width of the forest intersected by the road and rail line is more than 2.0 km.

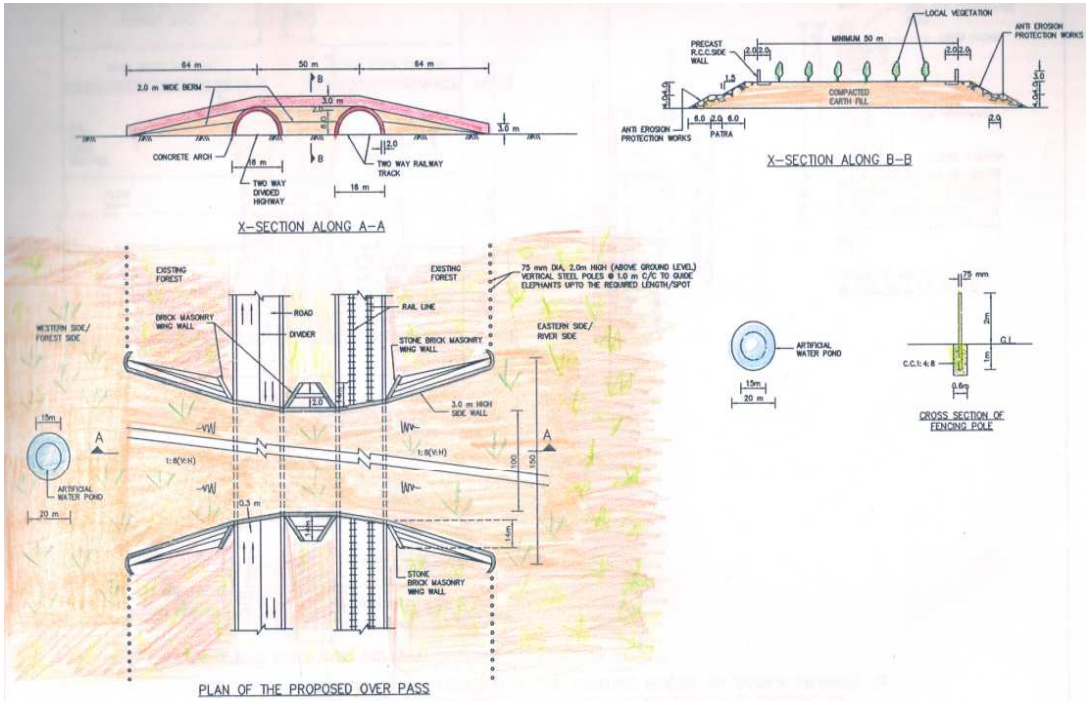
Fig. 6 shows the details of the proposed combined overpasses between river Motichur and Raiwala town over railroad and highway on the left bank of Motichur torrent. 16m wide, 8m high arches (keeping in view the future development) have been proposed to be constructed for railroad and highways separately.

While designing the overpasses, the width of the passage be kept as large as possible so that the elephants can cross together in a herd. To avoid audio-visual disturbance due to the traffic on the road and passage in trains, the passages should have a minimal width of 100m at the top and 150m at the entry/exit point of the overpass.

Prefabricated reinforced cement concrete side wall railing of 2.75m (above surface) height have also been proposed in the entire length of the passage so that the elephants are not disturbed visually by the moving traffic on the road. In the vertical walls, few pockets also be constructed and filled with the earth for growing some local vegetation or creepers. Slope of 8(H):1(V) has been suggested to negotiate 8m rise above the ground. Stone/Brick masonry wall have also been provided in the wing walls/sides to retain the earth fills. It has also been suggested to grow local plants and grass along the pathway as depicted in the Fig. 6 to provide eco friendly environment to the animals for adapting the overpasses. Water pools etc. be constructed at the entry and exit point of structure for attracting the animal to make use of an overpass. The authors are of the opinion that if they cross once and feel safe, then they will start using the overpasses regularly.

It has been observed that good number of big plants exist in the proposed alignment of structure and instead of cutting these trees, they may be encased in the structure to provide natural and congenial environment to the elephants. There are certain creepers, which grow on the walls and make the whole structure green with their leaves. Such type of creepers can also be planted on the surface of the structure. Colouring pattern matching to the surrounding landscapes may be adopted for painting the structures.

It has also been suggested that both the overpasses be connected with the 75 mm diameter and 2 m high vertical steel pole fence at 1 m centre to centre, so that the elephants do not try to cross through railroad and highways. Fig-7 shows the side view of steel pole fence near the overpass. The fencing should be suitably tied at the end of the forest area so that the elephants do not get trapped outside the fenced area. The fencing steel poles have to be properly designed and embedded because the elephants may try to dislodge the poles, as an elephant is a powerful and naughty animal. **Drg. No. 1** depicts the Proposed overpass between river Motichur and Raiwala town over rail line and road for the movement of elephants on the right bank of river Ganga in Rajaji National Park U.A.



Drg.No.1 – DETAILS OF PROPOSED OVERPASS BETWEEN RIVER MOTICHUR AND RAIWALATOWN OVER RAIL-LINE AND ROAD FOR MOVEMENT OF ELEPHANT ON THE RIGHT BANK OF RIVER GA RAJAJINATIONAL PARK



Fig.9-View of Combined Overpass under Construction on Rail line and Road in Europe



Fig.10

Fig.11



Fig.12

View of Overpasses made on Highway for Different Species in Different Countries

Species in Different Countries

Other Measures

It has also been suggested that the blowing of horn prohibited on the road/rail line around the structure. The movement of local elephants are not disturbed while using the structure. Elephant dropping can be placed near the entry and exit point of structures so that the elephants can have a feeling that the over pass is a part and parcel of the habitat. The elephant move/migrate normally between November to May every year. The construction activity of the proposed structures should be planned in such a way that all construction work is completed in one season between May to November. Fig.9 shows the photograph of combined Overpass constructed in the Europe to mitigate the rail line and roads simultaneously.

7.2 River training works to protect left bank of river Motichur and restoration of forest patch upto the river Ganga

On the western side of the proposed overpass, there is a good connectivity of forest. Whereas on the eastern side, the forest patch was washed away due to floods (on the left bank of river Motichur). Restoration of this forest is very much essential for the movement of elephants upto river Ganga, as it will provide the required level of security to the elephants while moving with infants and calves. There are army establishments / buildings and Ashram on the left and right bank of river Motichur in different colours and lighting of electric lamps and bhajans etc. have forced the elephants to avoid using this migratory route. As this is the only patch of forest which is connected to the proposed structure, so restoration of this forest patch is must for attracting the elephant's herds.

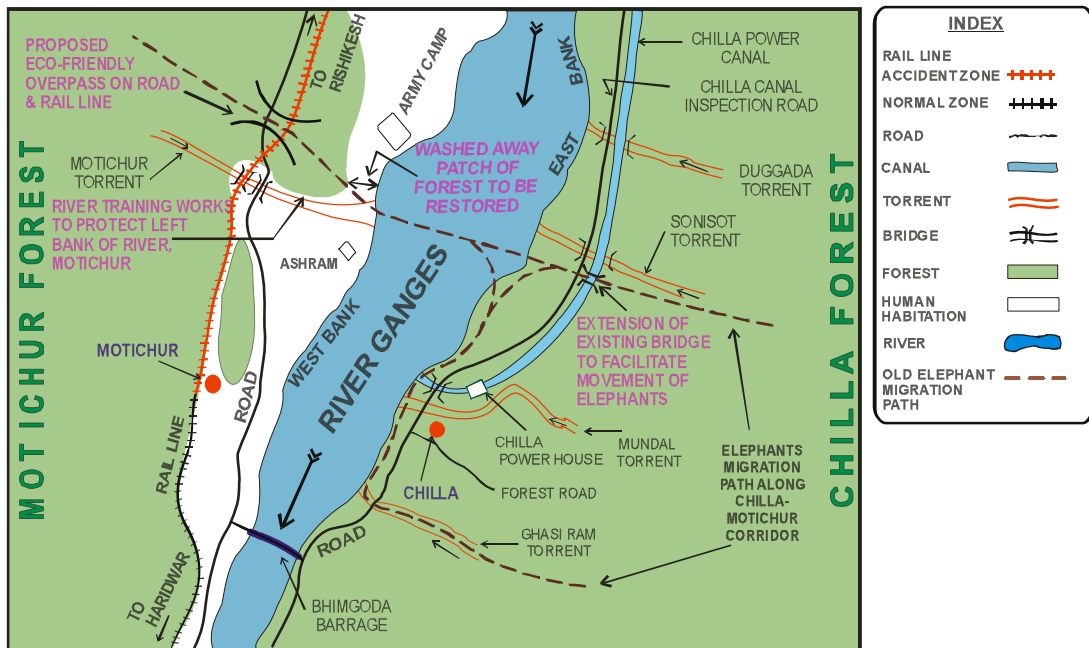


Fig.13–Location of Proposed Mitigation Structure in Chilla–Motichur Corridor

Construction of boulder bund, shanks, refilling of bund and the existing river bank by the river bed material shall also be provided for development of the river training works and restoration of forest patch.

the back space between the ateria etc. shall be involved in patch. Earth cushion over the opening the green forest in the

7.3 Extension of Bridge on Chilla Power Channel at chainage 12.50 km

On the east bank, the main obstruction is the power channel. The *Soni Sot* torrent is situated in front of *Motichur* torrent across the river Ganga, which is the main passage of Chilla-Motichur corridor. Almost every day, the elephants can be seen on the eastern side of the channel bridge, where there is a scarcity of water in the upper reaches of the forest. A 5.0 m wide concrete road bridge on the Chilla Power Channel at chainage 12.50 km (Fig. 14) has been constructed to cross the power channel. However, the bridge is not being used by the herds for crossing the channel due to its smaller width and low height of side railing. Occasionally the bull crosses the channel through this bridge. Therefore, it is proposed to modify/extend the existing road bridge on channels so that it can be accepted by the herds for crossing over to the other side of the forest.

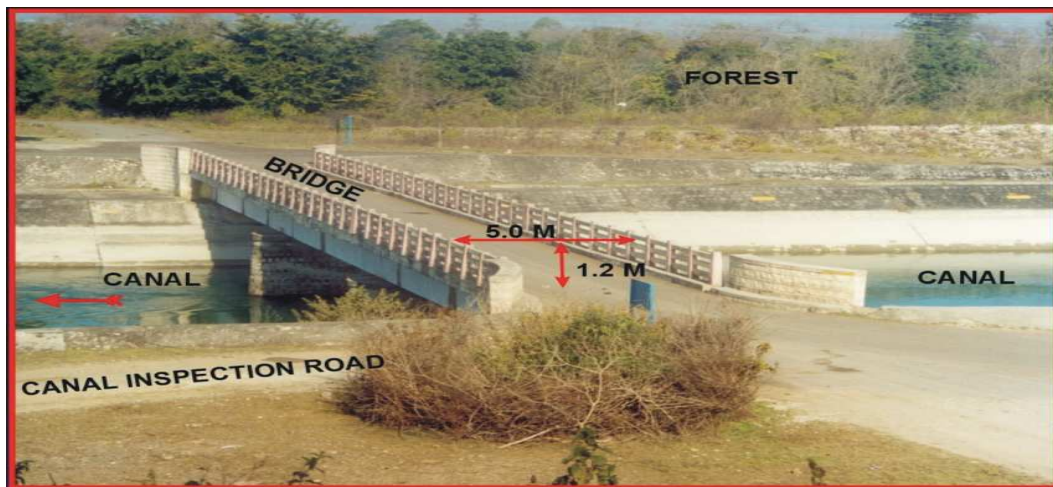
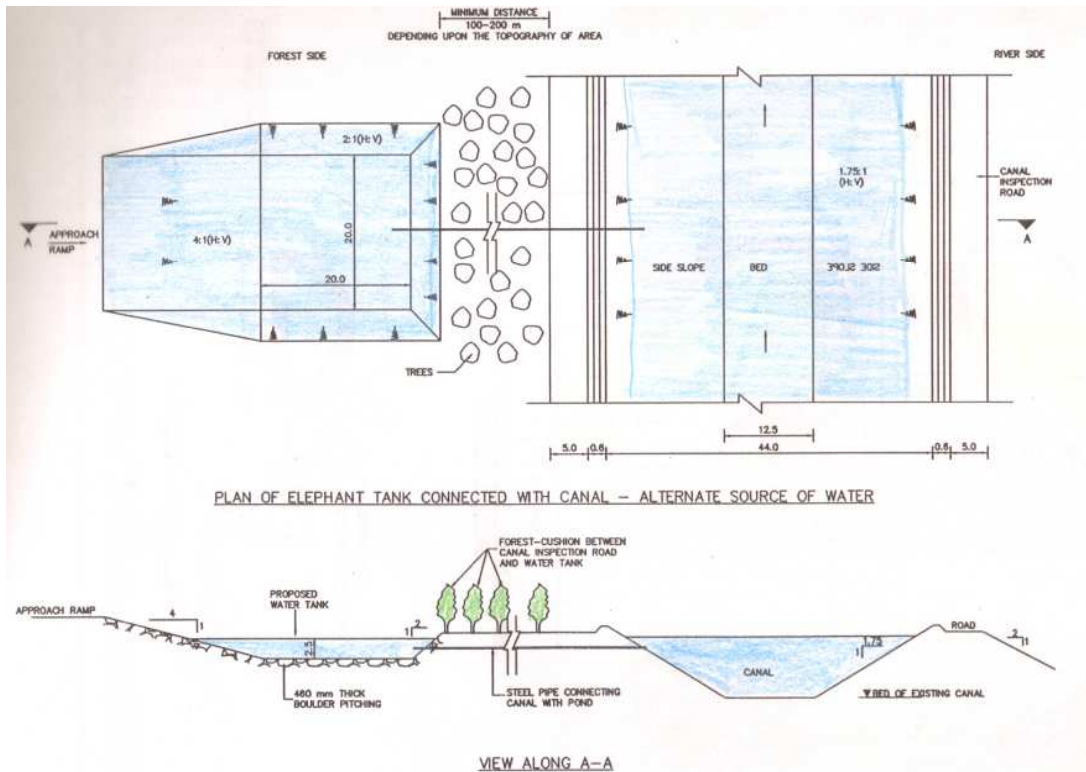


Fig.14-Photo of an existing bridge on the Chilla Power Channel

It has been suggested that the central pier and abutments be extended on both the banks so that the width of the bridge at the centre be made as 15.0 m and at the start/end as 25.0 m. It has also been suggested that the additional width shall only be available for facilitating the movement of the elephants on the bridge. It is proposed that the additional width on both sides of the bridge will have 30 cm earth cushion so that local vegetation and grass be grown on the top surface of the bridge, which will provide congenial atmosphere to the elephants for adapting the path for crossing over. Side railings of 2.75 m height have also been proposed to be constructed of reinforced concrete with 50% perforations and suitable pockets for growing local vegetation and creepers. **Dr. No. 2** depicts Modification/Extension proposed in the existing bridge on power channel of the Chilla Hydroelectric Project at km 12.50 near *Soni-Sot* torrent on Chilla-Motichur corridor in Rajaji National Park U.A to facilitate the movement of elephants.



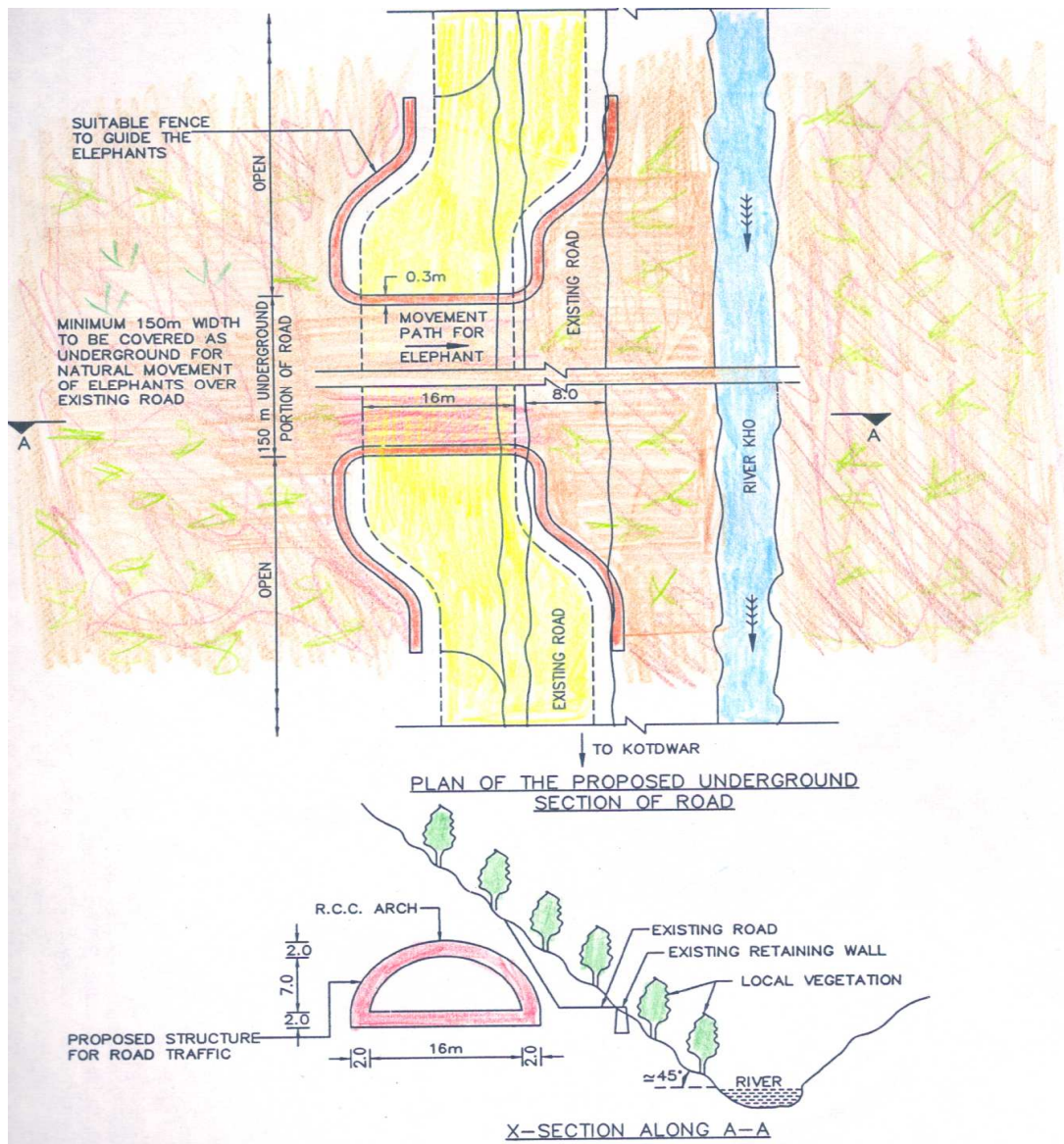
Drg.No.3 – PLAN SHOWING DETAILS OF PROPOSED WATER TANKS FED FROM CHILLA HYDROPOWER CHANNEL FOR ELEPHANTS AS AN ALTERNATE SOURCE OF WATER IN RAJAJINATIONAL PARK



Fig.15-View of Water Tank for Elephants connected with the Chilla Power Channel

7.5 Construction of Natural Passage over the existing Kotdwar-Lansdowne/Pauri Road

The Kotdwar-Lansdowne/Pauri highway is 8-10m wide. The valley side retaining wall and the back hill slope of the road is very steep. The authors are of the opinion that at this location, a natural passage across the existing hill slope can be provided by encasing the road as underground by shifting it towards the hills so that the wide passages can be constructed along the natural slope matching the surrounding landscape. The minimum width of the passage is proposed as 100.0-150.00m. **Drg.No.4** depicts the details of the natural passage by encasing the road underground in place of existing open road on the right bank of river Kho on Kotdwar-Lansdowne/Pauri road.



Drg.No.4 – DETAILS OF NATURAL PASSAGE BY ENCASING THE ROAD UNDERGROUND IN PLACE OF OPEN ROAD ON THE RIGHT BANK OF RIVER KHO ON KOTDWAR/LANSDOWNE/PAURI ROAD

Keeping the topographical conditions in mind, it has been suggested that 16 m wide, 7 m high and 150 m long underground tunnel with suitable approaches be constructed to pass the highway and the surrounding areas be given natural shape with forest and vegetation cover so that the elephants can start using the age old migration route again, presently hampered by the road. Suitable fence should also be provided on both ends of the road for the safety of the elephants.

The monitoring of these structures by some biologists may also be done to know the performance of the project or acceptability of the elephant towards different structures. To monitor the acceptability of structures, elephants dropping, urine and footprints, etc. may be observed. For monitoring, footprints, earth bed should be constructed across the structure and observed daily during peak movement times (Between November to May every year).

8.0 COST OF PROPOSALS

The cost of the proposed works for restoring the movement of elephants in the Rajaji–Corbett Elephant Range, India have been worked out to be approximately 4.5 Million USD only.

9.0 CONCLUSIONS/RECOMMENDATIONS

Elephant habitat in the Rajaji-Corbett Elephant Range have become fragmented and the corridors between these parks are no longer used by the elephants due to human disturbance and the barrier effect of busy roads, rail line and wide and deep channel.

In order to restore the lost migratory movement of elephants in the area, construction of Underpass, Overpass, alternatives source of water in the shape of tanks and restoration of forest cushion along the corridor in certain areas have been proposed in this report. It has also been suggested to increase the width of the existing bridge on Power Channel with suitable fencing and eco friendly environment so that the elephant herds can use the same for crossing over to the other side of the forest. It has also been suggested that the disturbance level by the road traffic near the migration structures should also be controlled by reducing the speed of the vehicles and prohibiting the blowing of horns. Sound dampners may be erected/placed by the side of the road/structure to reduce the intensity of sound of vehicular traffic using the road. Monitoring of the passages regarding the movement of elephants by some biologists may also be carried out to know the performance of various proposals so that they can be adapted at similar places.

It is also suggested that construction of various civil engineering mitigation structures alone is not sufficient for restoring the lost continuity. Co-operation of the local people living in the areas around the corridor shall also be required in restoration process and the corridor shall have to be protected from human and other settlements so that the animals do not have any hinderance in the area. It is also suggested that in future due attention be given to the protection of the corridor, while planning the developmental activities in the area.
