



ADB

May 2010

NEPAL North South Fast Track Project

TA 7135-NEP

Mission by Highway/Structure Engineer

Report by Martin J Fox

Review of Feasibility Study and Preliminary Engineering Reports

CURRENCY EQUIVALENTS

(as used in the Feasibility Study Final Report of May 2008)

Currency Unit	–	Nepalese Rupees (NRs)
NRs 1.00	=	\$0.0159
\$1.00	=	NRs 63.25 (March 2008)

ABBREVIATIONS

AASHTO	-	American Association of State Highways and Transportation Organisation
ADB	-	Asian Development Bank
BOT	-	Build, Operate and Transfer
DBFO	-	Design-Build-Finance-Operate
DFID	-	Department for International Development (UK)
DoR	-	Department of Roads
EIA	-	Environmental Impact Assessment
EIRR	-	Economic Internal Rate of Return
EoI	-	Expression of Interest
EWB	-	East-West Highway
FIRR	-	Financial Internal Rate of Return
FS	-	Feasibility Study
GAM	-	Goal Achievement Method
GoN	-	Government of Nepal
IRC	-	Indian Roads Congress
IS	-	Indian Standard
MCA	-	Multi Criteria Analysis
MoPPW	-	Ministry of Physical Planning and Works
NPV	-	Net Present Value
NRS	-	Nepal Rupee
O&M	-	Operation and Maintenance
ODA	-	Overseas Development Administration
PPP	-	Public Private Partnership
PPTA	-	Project Preparation Technical Assistance
TA	-	Technical Assistance
TRL	-	Transport Research Laboratory
UNESCAP	-	United Nations Economic and Social Commission for Asia
USD	-	US Dollar
VE	-	Value Engineering
WB	-	World Bank

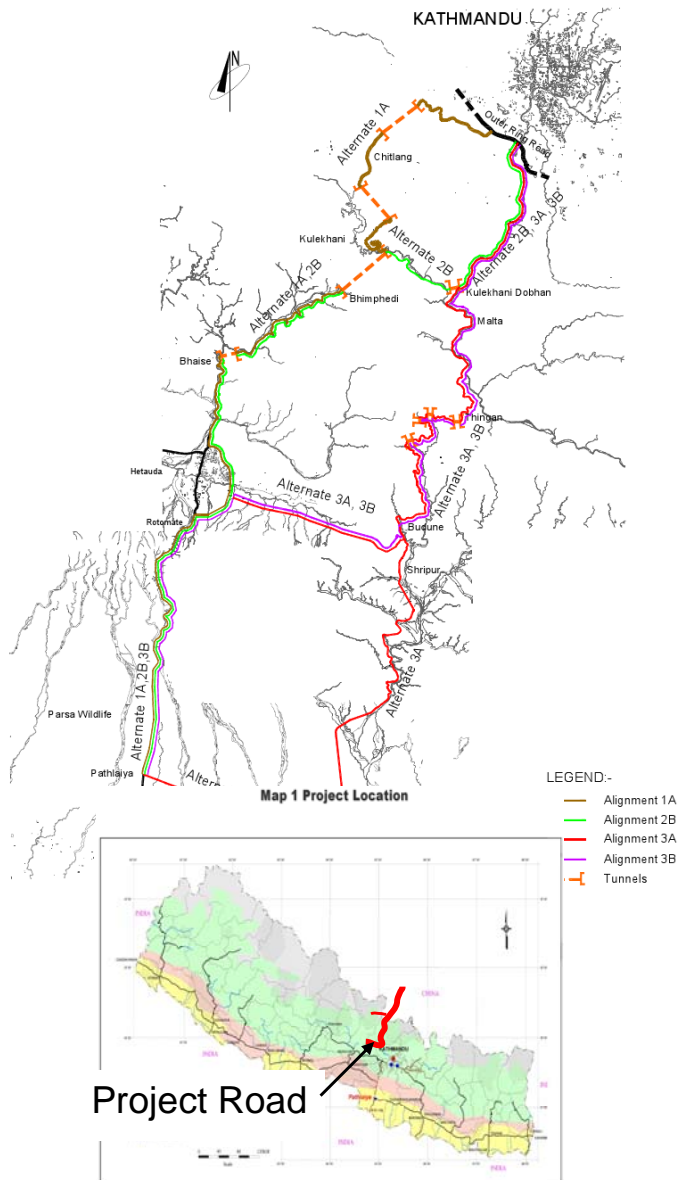
NOTE

1. In this report, "\$" refers to US dollars.

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Map of Project Area (taken from Feasibility Study Report)
MAP 3 FEASIBILITY ALIGNMENT ALTERNATIVES



Summary Part 1

The conclusions from the missions are:

1. The Feasibility Study (FS) looked at a reasonable range of alternative alignments (four).
2. Outcome of the FS was not as clear cut as may have been implied in the report, the results of the Multi Criteria Analysis (MCA) show that three of the alternative alignments scored very similar results. No sensitivity testing was reported on the outcome of the MCA by the consultants.
3. The basis of calculation of the project cost estimates for the various alternative alignments in the feasibility study was not presented (for example cost per km based on previous, similar projects in the region).
4. The selected alternative had neither the best net present value (NPV) nor Economic Internal Rate of Return (EIRR).
5. After commencing the Preliminary Design phase, the consultants found that access was more difficult than first thought, topographic survey work revealed more difficult terrain for a road than anticipated, and in order to meet the required design standards a large number of high cost structures were required.
6. The FS estimate for the selected alternative increased during the Preliminary Design to USD 902 million for a four lane road, USD 582 million for a two lane road.
7. No 're-visiting' of the alternative alignments was made or suggested by the consultants despite the large increase in the estimate.
8. Given the size and type of the structures and tunnel proposed in the Preliminary Design, additional geotechnical and geological mapping work is needed on the proposed alignment to give confidence in the estimated cost at a preliminary engineering level.
9. It is recommended that three of the original alignments (2B, 3A, and 3B) be re-examined and various combinations of road geometry, tunnels, and major structures be studied to arrive at an optimum solution for the project irrespective of which alignment is finally chosen.
10. With the amount of work done to date, it is reasonable to expect that such a variant study could be carried out in a period of four to six months.
11. The outcome of the variant study would, from an engineering perspective, permit the GoN to then proceed to tender the road (with the alignment selected in 10. above) for DBFO on a PPP basis if that is found to be the preferred option as the outcome of other processes.
12. Information was received during the first mission that the Nepal Army has commenced clearing an "access path¹" along the line of Alternative 3A, commencing near Makawanpurgadhi and heading north. The alignment in the section where this access path is being cleared cannot be considered as fixed in position at this time, as the consultants in their Final Report suggested re-evaluating the position of a 5 km long section of road in this area. The idea of establishing access to the alignment is a good one. It is not clear how much work is intended to be carried out by the Army as part of this 'clearing' exercise.
13. Clearing of an access path should be extended to the routes of Alternatives 2B and 3B. This would ensure access is possible to the Kulekhani Valley so that this route also can be better investigated by interested parties.

¹ Stated to be around 5-10 metres wide, and only intended as a pilot track to permit access.

Project Review – Mission 1 (8 to 23 March 2010)

I. Review of design criteria

1. In 1992, the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) endorsed the Asian Land Transport Infrastructure Development (ALTID) project comprising of the Asian Highway and the Trans-Asian Railway network as well as facilitation of land transport. The Asian Highway project is one of the cornerstones of ALTID.

2. The North-South Fast Track will form part of Asian Highway AH-42. Accordingly the design criteria should be at least those applicable to a Class I road of the Asian Highway. The minimum requirements are shown in the table below, together with the values adopted for the preliminary engineering design under PPTA 4842.

Asian Highway Class I			
Roads		<i>Adopted</i>	
Number of lanes	4 (2 x 2 lanes)	<i>4, or 2 with option to add 2 more in future</i>	
<u>Cross Section</u>			
Pavement width	7.0 m	<i>7.0 m</i>	
Shoulder width	Plain/Rolling	2.5 m	<i>2.5 m</i>
	Mountainous/Steep	2.0 m	<i>2.0 m</i>
Formation width	Plain/Rolling	12.0 m	<i>12.0 m</i>
	Mountainous/Steep	11.0 m	<i>11.0 m</i>
Right of way	Minimum 50 m	<i>50 m minimum</i>	
<u>Horizontal alignment</u>			
Design Speed			
	Plain/Rolling	100 kph/80 kph	<i>Typically 100 kph, nominally 80kph from 0-9km and 55-76km</i>
	Mountainous/Steep	50 kph	<i>Minimum 60 kph, nominally 50kph from 9-55km</i>
Minimum radius			
	Plain/Rolling	210 m	<i>250 m</i>
Superelevation	Mountainous/Steep	80 m	<i>150 m</i>
		10%	<i>10%</i>
<u>Vertical Alignment</u>			
Maximum grade			
	Plain/Rolling	4%	<i>4%</i>
	Mountainous/Steep	4%	<i>4%</i>
Minimum stopping sight distance	Plain/Rolling	120 m	<i>120 m</i>
	Mountainous/Steep	60 m	<i>60 m</i>

Asian Highway Class I		
Roads		Adopted
Pavement design	-no Asian Highway standard	Road Note 31 (TRL 1993, 4 th edition)
Bridges		
Loading	HS20-44 or IRC class AA	HS20-44 or IRC class AA
Peak discharge	-no Asian Highway standard	Rational method for catchment < 15 sq km Dickens or WECS /DHM method for larger catchments
Flood frequency	- no Asian Highway standard	1 in 100 years
Bridges		1 in 50 years
Culverts		1 in 20 years
Side drains		
Seismic Zone		IV and V of IRC-76
Tunnels	- no Asian Highway standard	Stated to be Japan Highway Public Corporation (JHPC) – no detailed information presented in Report

II. Review standards used in feasibility study

3. Although there is no comprehensive list of standards of used in the feasibility study contained within the Final Project Report, from a review of the three volumes the following table of standards likely to be applicable to the project road was prepared.

Source	Reference	Title	Year
UNESCAP - Asian Highway Network		Intergovernmental Agreement on the Asian Highway Network, Appendix II, Design Standards	2004
Indian Road Congress	6	Standard specification and code of practice for road bridges	2000
Indian Road Congress	6	Interim provisions for road bridges - Section II Seismic loads	2002
AASHTO		Standard specification for Highway Bridges	1992
MoPPW, Department		Nepal Road Standard	1971, revised 1989,

Source	Reference	Title	Year
of Roads, Nepal			currently still under revision
IS 1893 (Part I)	1893	Indian Standard Criteria for Earthquake Resistant Design of Structures (5th Revision)	2002 (Part 1) Part 3 covers Bridges and Retaining walls
DFID-Transport Research Laboratory UK	ORN31	Overseas Road Note 31 – A guide to the structural design of bitumen surfaced roads in tropical and sub-tropical countries	1993, Fourth edition
Japan Highway Public Corporation	JHPC	Design Principles, Volume 3, Tunnel (?)	Note: This document is not specifically referenced by name. The JHPC organisation is no longer in existence.
The publications below would be suitable alternative sources of design details for road tunnels:			
US Department of Transportation, Federal Highway Administration	FHWA-NHI-09-010	Technical Manual for design and construction of road tunnels, civil elements	2009
The Highways Agency, UK	BD78/99	Design Manual for Roads and Bridges, Volume 2 Part 9, Design of Road Tunnels	1999

III. Review competence of feasibility study and preliminary design

A. Technical

4. This section of the mission report examines the work carried out during the feasibility study for technical completeness, accuracy and competence.

1. Outputs from Study

5. The output from the feasibility study and preliminary design consists of four volumes of reports and appendices.

Volume	Section	Comment
1	Main Report	
2	Supplementary appendices - Alignment Selection - Design - Cost Estimates	
3	Supplementary appendices - Road Transport Sector Analysis - Regional Trade	

Volume	Section	Comment
	<ul style="list-style-type: none"> - Traffic Studies - Detailed economic analysis - Toll and Financial Analysis - Asset Management and ITS - Project Road Organisation - Road Safety 	
4	Drawings and Maps	In two parts

6. The overall and initial impression gained by reading the outputs from the feasibility study is that it covers all the areas which should be included in a study of this nature. The description in Section C.4 of the Introduction (Volume 1) details the time frame in which the various parts of the study were conducted. The initial feasibility study was done between April and July 2007, a period of around 3 months. After the GoN decision making process was complete the preliminary design and analyses were carried out between November 2007 and March 2008, a total period of around 4 months². The preliminary design was commenced in advance of topographic and geological surveys. A number of drawbacks are evidenced in the report due to this very compressed time frame. From past experience the time needed to carry out the preliminary engineering design of a green fields road project in difficult terrain is often under estimated. This appears to have been the case in this instance.

7. A Draft Final Report was submitted by the consultants and following the receipt of comments the Final Report was submitted in early May 2008.

2. Evaluation of alternative alignments

8. The scope of work required for the feasibility study was extensive, and included engineering, economic, social, resettlement, road safety and environmental aspects.

9. The consultants reviewed previous studies for a Fast Track project, from the UNDP study of 1974 to the 2003 NEPECON study of the Bagmati Corridor. No information was presented as to the original source of the alternatives studied or how the six alternatives were chosen for inclusion in the feasibility study. It appears that four of the alternatives correspond closely to alignments selected for analysis in the Finnconsult report of 1993.

10. One of the alternatives included for analysis was the upgrading of the existing highway from Kathmandu to Pathlaiya via Mugling and Narayanghat.

11. From the initial six alternatives four were carried through into the feasibility study proper. It is not clear which alternatives were examined by drive- or walk-over surveys and in what detail.

3. Multi Criteria Analysis

12. The consultants performed a multi criteria analysis on the alternatives. This is a technique commonly used in decision making where the number of input variables is large. Twelve criteria were used and the weightings arrived at by a process of estimation from a group workshop. No additional information on the rating and ranking of the criteria, leading to calculation of the weighting was given.

13. Details of attendees to the workshop were not given, and no comment as to the appropriateness (or otherwise) of the weightings can be made. For such a technique to be effective, all stakeholders in the project must be represented, in balance with the degree of representation they have in the project context, and must include the public sector, private

² Stated by consultants in Volume 1 Main Report, Appendix 5, page 5 at 33.

sector and civil society. Stakeholders whose livelihood or property will be affected are likely to have a different perspective on, for example, the importance of Resettlement Impact than a financier or employee of the Department of Roads.

14. The alternatives were presented in four groupings:

- Two lane with passing lane;
- Four lane;
- Two lane with passing lane, Hetauda – Pathlaiya 4 lane;and
- Rail connection.

15. The “GAM Index³” calculated for each proposal (Table 1.5 of Supplementary Appendix 1) resulted in five of the alternatives having values within the range 39.2 to 41.3 out of a possible maximum score of 52.8, a narrow range given the nature of the criteria.

16. This is a potential shortcoming of the process used to screen out the alternatives, given that the first and second ranked alternatives are almost the same (alternative 3B requires less new road construction than 3A) and 2B (Kulekhani River Route) is the shortest of all the alternatives, in potentially easier terrain than 3A or 3B (Bagmati Valley/Hetauda Routes).

17. To examine the sensitivity of the methodology the criteria were examined and the “operational viability” criterion selected. The way in which the ranking of “operational viability⁴” was perceived and scored is not commented upon. This is relevant as the alternatives 3A(2lane+passing) and 3B(all groupings) each scored 10.0 (the maximum) while alternative 2B(all groupings) scored only 2.0. A change in ranking from 2.0 to 5.0 (out of 10.0) would have put alternative 2B(2lane+passing+H-P 4lane) equal with alternative 3A. The ranking may have something to do with the fact that there were 3 significant tunnels in alternative 2B as against four very short tunnels⁵ in 3A. This degree of sensitivity was not noted.

18. The criteria for the MCA include Cost, Economic Viability and Operation Cost. There is a significant overlap between these criteria. All three have project cost as a common link. The Economic Viability is stated to be based on the EIRR and NPV of each alternative. These figures use the total project construction cost (here deemed to include land, resettlement, design and supervision, environmental mitigation costs as well as the construction costs), and the operation and maintenance costs over the life of the project.

19. In addition the Operational Viability is also reflected in the comparison of EIRR values for the alternatives, as the project costs include the costs of operating the road, tunnel and toll facilities. More complex installations will attract higher costs and lower EIRR values, as well as negatively impacting the Operational Viability.

20. This effectively represents a 'double counting' of these criteria. The list of criteria do not fit the requirement of a typical MCA that criteria be complete, non-redundant, and mutually independent of preferences. The MCA process was flawed in its approach.

21. Within the short time frame set for the assignment it would probably not have been possible to carry forward more than one alternative for further consideration in the context of a full feasibility level investigation. This is perhaps unfortunate and a failing of the study.

4. Construction Materials

22. The consultants have referred to construction material types in a number of places.

³ Goal Achievement Method

⁴ Stated as “the extent to which there is the domestic capacity to carry out toll, tunnel and road operations over the life of the project.”

⁵ See comments on page 13 about the change in tunnel configuration during the Preliminary Design Phase

In similar environments to Nepal it has been found essential to import large quantities of construction materials due to the poor and often inconsistent quality of steel reinforcement and cement. The aggregates required to produce high strength concrete must be angular in shape rather than rounded. This precludes the use of aggregate excavated from river beds as their shape is predominantly round. Even after crushing there remain some smooth and rounded surfaces which will result in concrete of lower strength. Aggregate for high strength concrete, required for prestressed components, will have to be crushed using stone from the rock cuttings along the roadway or other hard rock quarry sources. Locally 'produced' reinforcing bar often contains steel with a very high carbon content, resulting in excessively brittle material. Higher strength reinforcement bars are often produced by cold working the bars (by twisting), again leading to problems with ductility. Imported, high quality, high tensile strength bar is probably the only way to ensure a quality product for the major structures.

23. The consultants have correctly identified the need to import significant amounts of construction materials, cement, reinforcing bar, bitumen as well as specialised equipment and materials for tunnel and major bridge construction.

5. Geology and geotechnical investigations

24. The nature and extent of the geological and geotechnical investigations appears adequate for a feasibility study.

25. To progress from the feasibility stage to preliminary engineering design, especially with major bridge structures and tunnel(s), requires considerably more investigation than has been carried out to date. Given that there are seven major bridges between Km 29 and Km 45 and a 1.35 km long tunnel between Km 29+900 and Km 31+250 there is a need to carry out much more subsurface testing⁶. At each of the major bridge structures the consultant has proposed spread footings. It will be necessary to carry out investigations at the location of each pier and abutment for these structures.

6. Tunnelling

26. Construction of the tunnel represents a significant cost to the project (around 5% of the estimated total construction cost). Tunnelling is a high risk operation and often results in large cost overruns. In many cases these overruns could have been avoided or at least minimised by carrying out a proper level of investigation at the design stage. To carry out adequate design investigations it would not be unusual to spend between 1 and 2% of the construction cost of the tunnel (for the structure proposed this would amount to USD250-500,000).

27. It is considered that much more detailed geological mapping and investigation is needed to properly define the design parameters of the proposed tunnel. With the absence of tunnel building experience in Nepal in general and the project region in particular it is only possible to speculate on the range of problems which might be encountered. Additional geotechnical work, in the form of both seismic and drilling, will be necessary to permit detailed design of the tunnel to be carried out. Geo-radar penetration survey work is stated (p2-99) to have been carried out at both portals but neither the results nor the interpretations were found in the report.

28. This geotechnical investigation will be even more necessary should additional and/or longer tunnel sections be included at the detailed design stage.

29. The geotechnical work must include:

- survey and marking out tunnel line(s) from end to end;

⁶ Only one drill hole for the tunnel and a single borehole at 3 of the 7 major bridges were drilled.

- engineering geological mapping of rock outcrops in the vicinity of the line(s) by observing rock types, weathering, jointing and joint characteristics;
- reflection seismic testing using explosives in holes 1 to 2 metres deep; and
- rock core drilling including long inclined and near vertical holes, drilled as near as possible to the level of the tunnel line(s) and extending vertically down to at least the tunnel springline or floor.

30. Of special concern is the location of the tunnel, very close to the Main Boundary Thrust Fault and an alignment which makes an angle of 10 to 15 degrees with the strike of the rock beds. In addition the rock type in the area is shown as a Benighat slate with a dip of 54 to 60 degrees. The main tunnel axis is fortunately more or less at right angles to the general folding direction. Groundwater conditions are not known but need to be investigated. These are potentially very difficult tunnel building conditions. Tunnels on alternative alignments need to be examined in similar detail described above to properly evaluate alternatives at the feasibility/ preliminary design stage. The seismic performance of the tunnel should also be examined in detail.

31. With an overburden depth in excess of 400 metres it is likely that there will be some structural instability in the tunnel due to the very large compressive stresses and likely adverse orientation of the bedding planes of the rock. The method of construction adopted will reflect these perceived risks. Monitoring during construction will be necessary to ensure that safe working conditions are maintained and any remedial measures quickly implemented in the event of problems⁷. If alternative tunnel and/or route alignments are examined the depth of overburden on the tunnel(s) should be one factor to be input into the decision matrix.

32. The ventilation proposed by the consultants seems to be inadequate. Although no calculations of ventilation requirements were carried out they proposed jet fans be installed in pairs at 325 metre spacing. Given the age, condition, number and type of heavy vehicles likely to use the road, emissions in the form of soot and other particles from diesel fumes will be a problem. If a single tube is used for 2 lane traffic the fan number and spacing will have to be increased, particularly since it is likely that the heavy traffic will be relatively slow moving through the tunnel and the tunnel may well be used as a form of shelter or as a parking area for repairs. The increase in the number of fans will have an effect on both the tunnel construction cost and the operation and maintenance costs.

7. Survey and design errors

33. Possibly due to the rushed nature of the work a number of design errors were found in the geometrical design. This relates to the fact that design work was commenced in advance of receiving the survey data and changes were subsequently made to the alignment. This required a number of chainage 'breaks' to be inserted to permit the various sections of the road to match up with each other (for example at Km 24+725 where a break of 248.32 m was inserted). This is not a major problem and will be rectified during detailed design.

34. In addition, the location of bridges (as defined by the chainage (Km) along the road) varied during the preliminary design stage. Again this will be rectified during detailed design.

8. Bridge design detail errors

35. These errors are relatively minor and will be resolved during detailed design.

⁷ This is a standard feature of the NATM (New Austrian Tunnelling Method).

9. Major bridges

36. There are seven major bridges with overall lengths up to 327 m, main span lengths of up to 136 m, and heights over 100 metres. These structures are major bridges in any project context. Nepal has no previous construction history of such bridge types and the location in which they are to be built is remote and in difficult terrain.

37. The consultants have adopted a 3 cell concrete box girder section with d/b ratios varying from about 0.14 to 0.40. It is not clear why a 3 cell instead of a 2 cell section was adopted, particularly given the large values of d/b near the piers.

10. Seismic design

38. Given that the project region is crossed by major thrust faults, has a high seismicity risk profile, the ground is steeply sloping and there are adversely dipping rock formations, planning and design of large structures requires inputs from a specialist bridge design consulting firm. The consultants' report does not reference the IRC publication entitled IRC-6 (2002) "Interim provisions for road bridges - Section II Seismic loads". This represents a significant change in values of horizontal seismic coefficients⁸, a direct result of experience gained after the 2001 Bhuj (Gujrat) earthquake in India. Other relevant codes which relate to seismic design of bridges include AASHTO (American Association of State Highway and Transportation Officials) "LRFD⁹ Bridge Design Specifications", 2nd. Ed., Washington, D.C., 1998 and the Eurocode 8, "Design provisions for Earthquake resistance of structures" EC8/ENV 1998:parts 1-1 and 2. Experience gained from the recent Wenchuan earthquake in China on the design of highway bridges is also relevant to the Nepal context. The following reference from the 25th Annual lecture of the Indian Society for Earthquake Technology seems particularly relevant¹⁰, see box. Only general comments were made in the Final Report about the seismic performance of the various superstructure types considered. This is a critical area to be examined in more detail.

1. *"With the occurrence of every major earthquake, there has been in the past, almost a world-wide tendency to increase the capacity demand of the structure to counteract such events. It is only in the last decade that new strategies have been successfully developed to handle this problem economically. The current international practice has shifted towards a performance-based engineering design, wherein the accent is on serviceability and safety under different levels of magnitude of earthquakes. Also there is an increasing realisation that apart from techniques for improving ductility, the structural engineer's tool-box should include energy-dissipating and energy-sharing devices and those that can control the response of the system. There have also been further advances on appropriate methods and devices of preventing 'dislodgement' or 'unseating' of the superstructure in the event of severe ground shaking."*

11. Engineering details

39. Other design details which are not mentioned at all include the use of transitions on horizontal curves. For curves with radii below 200m the Nepal Road Standard requires that spiral transition curves be used, with widening. No mention of the incorporation of spiral transition curves, curve widening or superelevation transition was found in the design report.

40. Given the type of superstructure elements proposed to be used on the major bridges (prestressed concrete box girders) it is not wise to locate these structures partly on horizontal curves and partly on a straight. This requires that different and complex formwork

⁸ $\alpha_{2000}=0.144$ for longitudinal and transverse directions. $\alpha_{2002}=0.098$ for longitudinal direction and 0.270 for transverse direction.

⁹ LRFD = Load and Resistance Factor Design

¹⁰ 25th ISET Annual Lecture, "ECONOMICAL DESIGN OF EARTHQUAKE-RESISTANT BRIDGES", Mahesh Tandon, 2005

geometry be used for different parts of the structure. Simplicity is the key to economy and good construction quality¹¹. Similar comments can be made about the positioning of vertical curves on bridges. These are design details which should be amended during the detail design phase.

41. The slopes adopted for cuttings of various heights and materials appear to be generally conforming to the recommendations given in ORN 16¹², which has particular relevance for Nepal. One problem foreseen is that the bench widths are too narrow at 1.5 metres wide. This does not permit the use of mechanised equipment on the bench to clear fallen rocks or stabilise slides or slips and the bench widths should be increased

12. Pavement design

42. The pavement design is claimed in the report to be based on the British ODA/TRL Overseas Road Note 31. It appears that the thickness of pavement components detailed on p2-37 of Supplementary Appendix 2 are different to those shown in the Charts of the Structure Catalogue of ORN31 for class T8 and Subgrade strength classes S3 and S5. This is not necessarily wrong but comment should be made in the design report where a decision is made to adopt a different pavement composition, for example to reflect common practice in the country, or based upon experience gained on other roads in similar locations.

43. Of greater concern is the confusion caused by the consultants having used different values for the PCU factors¹³ in the traffic model and shown in the table on page A1-31 of Supplementary Appendix 6. The lower PCU factors exaggerate the traffic volumes used in the economic evaluation, but at the same time give higher values of the total number of equivalent standard axle loads over the life of the pavement. If the PCU factors claimed to have been used in the traffic model are also used for the pavement design calculations, the pavement as designed must be considered as marginal at best or inadequate at worst. For the section of road between Budune and Sripur the consultants adopted a Traffic Class (called Load Category by consultants) of T7. This may not be adequate if the lower PCU factors are used.

44. A summary of the pavement review is contained in Appendix 2 of this report. ORN31 is applicable for the design of pavements with less than 30 million ESAs over the pavement life.

45. Mention is made in the pavement design that one input parameter is a maximum deformation of 25 mm in the wheel tracks to define failure of the pavement, with intervention required at a deformation of 15 mm. This is not mentioned at all in ORN31. It is widely recognised that a better measure of pavement performance on roads such as this one is the roughness. One commonly used standard is the International Roughness Index or IRI. By measuring the roughness of the road the road operator can be required to target maintenance operations in those areas which fail to meet some predefined IRI criterion. Criteria can be included in the specifications for the operation and maintenance phase of the project.

46. It is common in rock cuttings to ensure that the bed of the cut is reasonably uniform in strength and can function as a select subgrade layer. This is generally done by requiring a degree of over excavation followed by compaction. The use of a 50mm thick levelling layer in a rock cutting (as proposed on pp2-37 and2-38) cannot be recommended. Where the material in the bed of a road cutting is not at least as strong as a Sub-base course it should

¹¹ More will be made of this at the Value Engineering Workshop

¹² ORN 16 Principles of low cost road engineering in mountainous regions, with special reference to the Nepal Himalaya, 1997.

¹³ This factor is used to convert vehicles of different types (cars, buses, trucks) to an equivalent "passenger car unit" or PCU.

be removed and replaced with suitable material.

13. Contract packaging and programming

47. The consultants included a section on contract packaging. As it is quite likely that the project will be a PPP project on the basis of some form of DBFO concession there will be a lead party (the project concessionaire) with overall responsibility for the implementation of the project. The packaging of works and the method in which the works will be carried out will be a subject for the concessionaire to examine and optimise, in consultation with the project owner (GoN).

48. The project report includes a section dealing with the implementation schedule. Two schedules were included, a pre-construction schedule (assuming a traditional project arrangement of design by a consultant, and construction by a contractor) and a construction schedule for the Civil and other works.

49. It is now clear that the pre-construction schedule has been significantly delayed. It is difficult to imagine that any detailed design work will commence before mid 2010 at the earliest, meaning that a slippage of 2 years has resulted. This will be reflected to some extent in the construction work, and it is therefore likely that construction will not be completed by the start of 2014 as envisaged. Given information available it is more likely that a DBFO contract might not be awarded before some time in 2011.

50. The consultants have shown a four year construction period. Experience elsewhere suggests that this might be an over optimistic figure, given the terrain, complexity of the works and the level of finance required. Under a DBFO system it is possible to design part of the works and commence construction in advance of finishing the entire project design. This is particularly applicable to sections which are easily accessible to existing roads (for example the Hetauda connector or the section from the East West Highway at Nijgadh north to Budune). An earlier commencement of works would permit some 'fast-tracking' of the project to be achieved.

51. The delay in commencing the project will have an impact on traffic forecasts, calculation of toll rates, and the financial and economic analysis of the project.

B. Financial

1. Feasibility estimate

52. A feasibility level estimate of the cost of the alternative projects was carried out during Phase 1. The basis of calculation of these costs (shown in Table 1.2, p1-3) is not given in the Final Project Report. It is not known how the consultants arrived at the estimated cost and no sensitivity checks were done. Although not explicitly stated, it seems that the estimated construction cost was calculated on the basis of constructing two lanes with passing lanes (Table 7.2, p7-5, has total cost for 2 lane option on Alternative 3A as NRS 13,780 million. At an exchange rate of 63.25 this is approximately USD 218 million, the figure in Table 1.2).

53. It would seem that values of EIRR and NPV for each alternative were available to the workshop which carried out the multi criteria analysis of the alternative alignments in Phase 1.

54. More details on the financial aspects of the review are contained in Part 2 of this report.

2. Discrepancies and inconsistencies

55. There appears to be 'versioning' problem (incorrect references to Appendix number) in the Main Report and the Supplementary Appendices which occurred between the time of preparing the Draft Final Report and submitting the Final Report.

56. Another, significant, inconsistency noted is that in Phase 1 of the study, Alternative 3A, the alternative selected for further study in Phase 2, had four small tunnels (0.50km, 0.30km, 0.25km, and 0.35km).

57. The operation and maintenance cost of tunnels with these lengths would be relatively low as there would be no need for artificial ventilation and only minimal lighting requirements.

58. In Phase 2 these tunnels were eliminated and one single tunnel of 1.35 km length was included.

59. This length of tunnel will definitely need ventilation¹⁴ and lighting, will therefore be more expensive and have higher O&M costs. The comparison of costs of the Phase 1 alternatives with respect to tunnel costs (capital and O&M) is therefore to be viewed with caution. The design report states that the change in tunnel configuration was made to improve the alignment (324., p2-107, Supplementary Appendix 2). Table 7.4 of Supplementary Appendix 7 includes O&M costs for both Phase 1 and Phase 2 cases and reflects this (significant) increase.

60. There is a further inconsistency in length of road for Alternative 3A presented in Tables 1.2 and 7.16/7.17 of Supplementary Appendices 2 and 7 respectively. It is assumed that the difference somehow relates to the Hetauda Connector and/or changes in road length following the topographic survey.

61. There are discrepancies in the currency exchange rates used in different parts of the report. A base rate of NRS63.25:USD1.00 is noted in a number of places (and used in this report). A Shadow Exchange Rate of 70.6 is stated to have been used to derive economic costs of principal tradable items.

62. Table 8.17, Expressway Capital Costs (Supplementary Appendix 8, p8-23) contains a table of both NRS and USD which seem to reflect an exchange rate of over NRS73:1USD. No clarification was found to explain the use of this figure.

3. Use of 'norms' and rates from other countries

63. The consultants state that they have used the DoR published "Norms for Rate Analysis" for many of the cost items. Experience in other countries where the use of such 'Norms' is common is that they are often much higher than the rates which are tendered by major/international contractors. The consultants further state in Supplementary Appendix 3 (p3-5) that they have used prevailing unit rates from contracts of similar projects in Nepal. It is not clear how much use was made of the Norms in preparing the project estimate. Additional data would be necessary to analyse the estimates in more detail.

64. The comparison of construction costs per kilometer between PRC and Nepal overlooks the fact that:

- Reinforcing bar, cement, and bitumen are all produced 'locally' in large quantities at relatively low cost in PRC
- Trained labour for bridge and tunnel construction exists in large numbers in PRC
- Specialised equipment for bridge, road and tunnel construction is made locally and is

¹⁴ Tunnels 500 to 800 m long can be built without ventilation. From 500 to 4000 m, and with two way traffic, axial ventilation is generally sufficient. If there are no pedestrians this upper limit may be increased to 7000m.

widely available in PRC.

65. It is therefore possible that the comparison of costs between the Fast Track (estimated at USD10m/km) and projects in PRC (construction costs in the range USD 6 to 9.5 m/km) are not appropriate and that the estimated cost for the road in Nepal is too low.

66. Tunnel construction cost estimates are generally less reliable than road or bridge estimates. It is not known if a higher percentage for contingencies has been allowed when preparing the tunnel estimate.

C. Safeguards

1. Environmental

67. The Final Project Report contains only a preliminary environmental assessment of the project. The report cites concerns about the effect of other alternatives on the buffer area of the Parsa Wildlife Reserve. The official map of the park (taken from an image on the website of the Department of National Parks and Wildlife Conservation¹⁵ indicates that the buffer areas of both the Park and the National Forest to its south are located almost entirely on the western side of the existing Hetauda-Pathlaiya roadway. If the project is constructed in stages, for example the first stage being to construct the new road from Kathmandu to Hetauda and to use the existing (possibly upgraded) road from Hetauda to Pathlaiya, the environmental arguments against the alternative alignments appear to be significantly weakened.

68. It may be worthwhile to examine the feasibility of constructing a new section of the Hetauda-Pathlaiya road completely outside the buffer area referred to above. This would have the advantage of construction work not interfering with existing traffic on the road from Hetauda to Pathlaiya. After the staging plans are finalised a detailed program of Environmental Impact Assessments must be drawn up and implemented.

69. The content of the preliminary assessment covers the range of topics required for a consideration of the environmental impact. It is satisfactory for a feasibility study but more work is necessary before it can be considered adequate for a preliminary design report. Almost all the points raised in the environmental assessment are generic and not project specific. At the preliminary design stage it is normally expected that a specific and suitably detailed environmental assessment, relating to the actual alignment chosen for preliminary design, is carried out. Included in the report must be details of mitigation measures addressing problems foreseen along the road. These measures are to be fine tuned during the detailed design process, included in the Contractor's mandatory requirements, and monitored throughout the construction and operation of the project road.

70. Most of the above points were recognised by the consultants and they proposed (Appendix A16.1) in summary form a procedure to carry out an Environmental Impact Assessment and the preparation of an appropriate Environmental Monitoring Plan. Other than the requirements to obtain acceptance/approval by the ADB the procedure is applicable to the project irrespective of the source(s) of funding or modality of implementation.

71. From past experience on road projects of this nature and other projects in Nepal, significant features of the long term environmental management of the project will include the bio-engineering and other slope protection measures necessary to promote and enhance the stability of the slopes adjacent to the road, the bridge and culvert foundations and river banks where river training works are implemented.

72. Measures during construction to prevent pollution of rivers, water courses and groundwater, as well as minimising the impact of construction activities on forest areas, flora

15 See www.dnppwc.gov.np/wildlife-parsa.asp, www.dnppwc.gov.np/maps/large9jpg.jpg and the map in Appendix 3

and fauna must be made mandatory for the contractor to implement, monitor and report.

73. Base line assessments and ongoing monitoring and evaluation by independent sources should be implemented by the GoN.

2. Social

74. The consultants carried out only a 'broad brush' overview of the social aspects of a study. This consisted mainly of sets of statements generic to any construction project in the context of a rural road in a developing country. Mention was made of:

- Resettlement Impacts;
- Social and Poverty Scenarios;
- Indigenous People;
- Gender aspects of the project; and
- HIV/AIDS.

75. The main report states (p29) that initial social and resettlement screening was carried out for all the probable alignments. No results of these screenings have been included in the report. This work will need to be carried out when the alignment of the road is finalised and a formal resettlement survey, as well as a complete social impact assessment, carried out in advance of full construction work.

76. As mentioned elsewhere information was received during the mission that the Nepal army has commenced clearing work on the alignment east of Hetauda. It is not known what this might mean for both the social and environmental impact assessments.

IV. Review suitability of technology and construction methods

77. This section contains comments on the preliminary design as it has been presented having regard to constructability, technology available in Nepal or the region, and construction methods in general.

A. Programming of works

78. Construction programming will be an important factor in the project implementation. Access along the alignment is a real problem. It may be worthwhile to commence construction from the south and use the newly constructed roadway and bridges to gain access to some of the more isolated northern sections. Sequencing of construction may have a bearing on the type of structures. The consultants noted that transport of heavy steel components made steel bridges generally less attractive than concrete ones. If access is not a problem the use of (for example) steel truss bridges may be economically and technically feasible.

79. Construction of the Hetauda Connector at an early stage would give access to the main highway for transport of construction materials by heavy trucks from the south.

B. Tunnelling

80. Tunnel construction is a specialised field employing many techniques and equipment which are generally not used elsewhere on a highway construction project. As such there would be a possible 'economy of scale' should additional tunnels be incorporated into the project design. The mobilisation and set up costs of the tunnel contractor would be spread over more than one installation, and experience gained while driving the first tunnel would be

valuable for subsequent drives. This would support the idea of perhaps including additional tunnel(s) to replace at least some of the long, high bridges.

81. The consultants proposed that a rock breaker and backhoe excavator would be used to excavate the tunnel, without the need for blasting. Construction would proceed using the micro-bench method with an initial ring cut. This method is commonly used, simple in its application and may be appropriate on this project (refer to previous comments on geotechnical investigation work). Monitoring of deformation during excavation will be required to ensure the stability of the tunnel. Given the bedding plane orientation it may be necessary to employ special head plates on the rock bolts to optimise the transfer of the compressive force from the bolts into the rock in the vicinity of the excavated surface. It is also possible that forepoling or spiling (horizontal grouted bolts) will be needed in some areas to maintain the integrity of the crown during excavation.

C. Bridge types

82. Bridge types have been commented on in some detail by the consultants (Supplementary Appendix 2, VIII.D.1. Possible Bridge Formats p2-79ff).

83. The level of technology required to construct the type of bridges proposed is far in excess of that used in Nepal to date.

84. The use of long span bridge configurations results in a lower impact of the structure on its environment (especially at river crossings) but leads to problems with 'technology creep'. Shorter span bridges, up to around 30m, can be constructed using ordinary prestressed concrete techniques. Above this figure, concrete bridges must employ a box girder section for the superstructure, employ an arch form, or be cable stayed in some form. The use of these types of bridges significantly increases the demand on the contractor's skills to perform work of the necessary quality and to the tolerances required, as well as significantly driving up the cost of construction.

85. Box girder bridges built on curves require consideration of torsional and as well as longitudinal bending. For this reason the bridges should wherever possible be built on straight sections of road. The height of the main bridges will require the use of a balanced cantilever or some form of launching gantry system. The main span lengths are probably too long to use an incrementally launched system.

86. There are many bridges in China where the concrete truss arch form has been used, with spans in excess of 300 metres, up to 250 metres above the valley floor (see concept sketch at right).

87. This type of structure was dismissed by the consultants on the grounds of complexity. It is likely that construction of the balanced cantilever type of bridges proposed by the consultants will be just as complex as the truss system, neither type being of a format which "falls within the category of a 'simple structure' as proposed" in the Final Report¹⁶.

88. The consultants adopted a box girder section for the long span bridges. It was noted that steel truss bridges could be further investigated at the 'final' design stage. Experience has shown that erection of steel truss spans up to 120m are quite achievable without the need for falsework or intermediate supports¹⁷. Examples of this type of bridge (two lanes wide, full highway loading) have been built in thousands of different locations in many countries in South East Asia. Erection, and subsequent maintenance, is much simpler than a concrete structure of the same span. Individual component weights are such that no special transportation requirements are necessary. This type of structure, while not aesthetically the most pleasing, could represent a substantial cost saving for the project.

¹⁶ Supplementary Appendix 2, p2-78

¹⁷ For example the IASBP – Indonesian Australian Steel Bridges Project 1980 - 1992

D. Bridge maintenance

89. A consideration which was not addressed in the comparison of bridge types is the specialised maintenance requirements for high, complex structures. Inspection of the underside of the superstructure elements requires the use of special inspection platforms, similar to the one shown in the picture on the right.

90. Such a platform permits the inspection and maintenance of long, high bridges to be quickly and safely carried out. No access from below is necessary. There will be no possibility to hire such equipment and the contractor responsible for maintenance will have to purchase such equipment. In addition to regular inspection and maintenance box girder structures must be designed to permit periodic maintenance operations such as bearing replacement. This is a non-trivial exercise on bridges of the type, height and span lengths proposed.

E. Retaining structures

91. Retaining structures will play a crucial role in ensuring that the road integrity is maintained. As such it will be essential that they are constructed to a high quality.

92. Of concern in some countries is the local fabrication of gabions from local wire. The quality of the baskets (uniformity of mesh size) is always questionable and usually the baskets end up with a mixture of large and small openings. The stone size used is often too small and the combination of small stones and large openings threatens the integrity of the baskets. In addition the failure to properly wire the rows of baskets together means that the completed structure is unable to withstand the deformation intended by the designers in situations where scouring under or around the structure occurs. These matters are relatively simple to control.

93. The consultants have proposed the use of "Reinforced Earth"[®] type¹⁸ structures for the higher walls (5 to 18 metres in height). While the principles involved are simple there are a number of factors to be taken into consideration during construction. Where steel straps are to be used they must have the correct shape and strength, be protected against corrosion and be without kinks or bends. The concrete facing panels are to have the attachments for the panels properly embedded and protected against corrosion. The backfill material must meet the minimum requirements of the design with respect to chemical properties, size and composition (pH, Chloride and Sulphate content, grading, resistivity etc). The material used for backfilling must not break down over time, and the use of shales or other friable materials is not permitted. Generally the manufacturer of the product supplies typical material specification requirements and these must be adhered to if the design life of the wall is to be achieved. Where galvanised steel straps are used it is essential to ensure that the galvanising coating is not damaged during the placement and compaction of the backfilling.

94. Gravity or Reinforced Concrete retaining walls without anchors require careful attention to the foundation detail as failure most often occurs as a result of scouring or sliding under the toe of the wall. Such walls should be used only in situations where sliding or slope instability can be prevented.

¹⁸ The generic term used is Mechanically Stabilised Earth (MSE) and may include Reinforced Earth, Tensar Geogrids and other proprietary products.

F. Bio-engineering and slope stabilisation

95. The consultants have prepared a comprehensive array of slope stabilising measures using bio-engineering techniques. It is essential that these measures be properly implemented and - even more importantly – be maintained in the early life of the project. Monitoring must be employed to ensure that any problems observed are fixed as soon as possible. Fortunately the techniques proposed are not “high technology” and can be carried out by local workers under appropriate supervision.

Comment [Martin Fo1]: Here is a book mark to show the end of the report. It is used for generating page numbers