NOTICE

Dated 26th May 2022

Sub: Request to participate in virtual session on **"Value Engineering Practices to the Design, Construction & Maintenance of National Highways Projects"** hosted by MORT&H on 31st of May, 3-5pm

Sir/Madam,

The Ministry of Road Transport & Highways is in the process of finalising guidelines on **Value Engineering Practices to the Design, Construction & Maintenance of National Highways Projects**. A draft circular along with its appendix is enclosed.

It is requested that all the stakeholders may participate and contribute his/her valued and experienced suggestions to the profession. The VC link of the same will also be displayed on the MORT&H website on 31st May 2022 well before the meeting. Also one can compliment/supplement his/her suggestions with back up details & calculations to following email:

bidurkant.jha@gov.in

Subject: - Value Engineering Practices to the Design & Construction of National Highways Projects – reg

Madam/Sir,

Government of India has set an ambitious plan for development of National Highways in the country. Many initiatives have been taken to materialise this ambitious plan such as adopting worldwide best practices in engineering techniques in design and construction of highways and bridges. Further, need is felt to adopt value engineering practices in design, construction and maintenance with regards to use of materials and technology as an important and vital step to meet the sustainable development of the NH network throughout the country in a cost-effective manner with improved durability & safety, de-carbonise & grow, reduction in project execution timeline, increase in quality and reduction in maintenance.

2. The value engineering is very crucial for sustainable highway development. It is a systematic method to achieve the targeted function of the highway at the lowest whole life cost, without compromising on quality, performance, safety, and aesthetics. Value Engineering practices aims at optimizing the value of the project at various stages viz. project conception, project preparation, project bidding stage and project implementation to achieve at least one of the following objectives:

a. Increasing the speed of construction

b. Reducing the cost of construction

c. Increasing asset durability

d. Improving aesthetics and safety

e. Promoting environmental sustainability

3. Value engineering can be applied at various stages in a project including construction. However, the earlier it is applied, the higher are the returns. As per World Bank report on Indian Road Construction Industry, it has been established that the savings realized by undertaking value engineering exercises can be in the order of 10-15% of the cost of the originally designed project.

4. The model of EPC or HAM or BOT project has the potential that the Contractor or the Concessionaire would be able to adopt designs and construction methodologies to suit the requirements of the project to bring down the cost while not impacting other aspects such as functionality, quality or durability. Although a facilitative provision for value engineering is laid out in the governing IRC Manuals for highway projects (IRC SP 73/84/87), however contractors or concessionaires, out of an apprehension that the authorities would take adverse views about any alternative technologies, avoid any deviations from the specifications/technologies sought for in the bid documents. There is no prevailing contractual facilitation for value engineering in NH contracts which would compel the contractor and IE/ AE to adopt value engineering. The possibility of alternative design schemes, use of new

and marginal materials, technology, and waste materials entirely depends on contractor's/concessionaire's choice and its approval by the IE/AE.

5. To add value engineering practices for design & construction of National Highway, following has been decided:

5.1. Value Engineering shall be assigned as one of the task in the Terms of Reference (ToR) for Feasibility Study and Detailed Engineering Projects. In Inception Report itself there shall be a Chapter regarding Value Engineering, in which Consultant shall include the potential & project specific value engineering aspects identified by the respective domain experts based on site reconnaissance surveys. In the Feasibility Report, Consultant shall examine the applicability, constructability & appropriateness of the identified value engineering aspects and recommend the cost-effective one. During design stage, design shall be done for the finally adopted value engineering aspects and considering the same Schedules and Project Cost shall be prepared. The typical value engineering concepts are given in **Appendix-1**.However, in addition to the same other value engineering aspects shall also be explored.

5.2. Annual Plan Preparation shall also keep in view the possible Value engineering aspects.

5.3. During the Project appraisal, in PATSC/SFC memo, there shall be a para regarding Value engineering Practices examined and finally adopted.

5.4. Further during implementation, the Contractors/Concessionaires should be allowed to propose value engineered alternative design/innovative material/ technologies. AE/IE shall review the proposed value engineered design and if it is not reviewed within the stipulated time, Contractors/Concessionaire shall submit it to 3-member committee under the chairmanship of DG (RD&SS). In 3-member committee, one member each from NHAI and NHIDCL shall be nominated. The 3-member committee deliberate the proposal and recommend for its acceptance or rejection. The distribution of savings in cost for the negative change of scope due to reduction in length of highways/bridges/tunnels between Authority and Contractor/Concessionaire may be 50:50.

Appendix-1: Formulation of Value Engineering Strategy for National Highway Projects

The cost component of a highway project generally comprises of 70% of Material costs, 20% of Machineries costs and 10.0% of Manpower costs. Hence, to have a value engineered optimum highway emphasis shall be on material selection and design.

1. **Policy for Design & Construction of Futuristic Flexible Pavement (FFP)**

Flexible Pavement (New Construction) shall be designed for maximum allowed effective subgrade design CBR 15.0% as per IRC: 37-2018. It can be achieved

1. using select soil (either borrow or excavated) of required CBR for subgrade and embankment construction as per IRC:37 and MORT&H Specification,
2. improved subgrade upper layer(top 250mm) using select soil treated with hydrated lime/cement/fly ash/pond ash/commercial cementitious stabilisers/liquid additives/Nano technology/geo-synthetic(geo-textile/geo-grid/geo-cell) etc. as per IRC:37, MORT&H Specification, IRC:SP:89(Part I & Part II) and IRC:SP:59-2019,
3. using mechanical modification of select soil blended with Pond Ash/non-plastic soil/sand/gravel/mining waste/crushed aggregate/reclaimed granular material etc. in subgrade layer construction as per IRC:SP:89(Part I)

For stabilization, purpose-built soil stabilizer shall be used. Use of indigenous equipments/plants/machineries shall be encouraged.

Enhanced quality control more particularly the compliance of minimum specified compaction, 4-days soaked CBR at specified density and design stabilizer content shall be met in construction.

Benefits of Futuristic flexible Pavement (FFP)

i. Exploitation of maximum soil strength using technology (as we cannot minimize earthwork quantity for a particular design road level)
ii. No need of any re-work in subgrade at the time of rehabilitation i.e. it is compatible with future maintenance/augmentation etc. i.e. futuristic pavement
iii. Enhanced performance
iv. Reduction in designed pavement composition i.e. lesser thicknesses of subbase/base/bituminous layer (reduction of DBM thickness in the range of 20-50mm) i.e. a cost reduction in the range of 5-15.0 %
v. Less consumption of aggregates
vi. Less burning of bitumen i.e. lower emission of Green House Gases(GHG)
vii. Cost-effective, durable and environmentally sustainable.

2. Design Period for Bituminous Layer of Flexible Pavement

Currently, bituminous layer is being designed for 20 year design period. Bitumen is an organic material, which oxidises with time. There is no perpetual bitumen. Experience gained over the years confirmed that the maximum performance period of bituminous wearing course is limited to 8-10 year. After that it requires renewal course. Nothing can be designed beyond its performance period.

Further, to have at least 30-40% remaining life prior to overlay with renewal course, it is prudent to design it for 15 years design period initially.

3. Rational Inputs for Rate Analysis

Presently, inputs used for rate analysis is not closely simulated with the inputs taken by the developer in actual construction. That is why, there is a bidding cost difference in the tune of 20-30% lower side than that of Ministry. To have more closely simulation or rate analysis at same platform, following strategy can be adopted.

i. The minimum rate of bitumen from the Government refinery and private producers shall be taken.
ii. The minimum rate of Steel from the SAIL/TISCO and private manufacturers shall be taken.
iii. The rate analysis of concrete shall be taken considering 20 per cent fly ash by weight of total cementitious material.

4. Suggested Flexible Pavement layer Combination – All designs and estimations shall necessarily be based on actual optimal requirements for layer thicknesses as per IRC: 37-2018. Suggestive thicknesses as per catalogues (Ref. Section 12 of IRC: 37-2018) shall not be used even for estimation purposes.

- **For design traffic<=10msa**

15.0% effective subgrade CBR+200mm CTSB+50mm BC with VG-40 or 150mm GSB+105mm RAP+40mm BC with VG-40.

- **For design traffic>10msa and <=50msa**

The flexible pavement layer combination shall be 15.0% effective subgrade CBR+CTSB+WMM+DBM/BC.

- **For design traffic>50msa**

The flexible pavement layer combination shall be 15.0% effective subgrade CBR+GSB+CTB+AIL/SAMI+DBM/BC.

5. Use of Glass/Carbon/Aramid Fiber Reinforced Polymer Rebar for non-load bearing/ minor CD Structures

Fiber Reinforced Polymers (FRP's) are a proven and successful alternative reinforcing that will give structures a longer service life. To reduce the demand of conventional reinforcement for highway projects, it is prudent to allow **Glass/Carbon/Aramid Fiber Reinforced Polymer Rebar** for non-load bearing structures like Crash barrier, Drain and minor CD structures i.e. Hume pipe Culvert and box Culvert. There is a reduction of 5-10% of the cost.

As the IRC Guideline for the same is in the process of finalization, till then the design standards & Specifications to be referred are

- **AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings, First Edition.**
  - Published in November 2009, this document offers authoritative design guidance to the bridge design community in safely adopting FRP bars in bridge decks and railings.
- **CSA S-806 – Canadian Code**
  - "Design and Construction of Building Components with Fibre-Reinforced Polymers".

- **CSA S-6 Canadian Highway Bridge Design Code**
  - Widespread adoption of GFRP bars in Canadian bridge structures is being made possible by this important document.
- **ACI 440.1R "Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars"**
  - The American Concrete Institute 440 guide is a mature and living document that as undergone a number of revisions since its first publication in 2001. Companion documents to the 440.1R design guide include the ACI 440.3R "Guide Test Methods for FRP's for Reinforcing or Strengthening Concrete Structures" which is intended as an interim document superseded by new ASTM test methods as they become available.

International Studies

- **FIB Task Group 9.3 – bulletin 40 "FRP Reinforcement in RC Structures"**
  - **In Europe, the Federation Internationale du Beton FIB Task Group 9.3 has published a technical report "Bulletin 40", which is a "state of the art" of FRP reinforcement in RC structures. Work is under way on provisions for FRP bars in Euro Code 2 format. Norway and Italy have published internal design codes for the use of FRP bars.**
- **4th Structural Specialty Conference of the Canadian Society for Civil engineering Montréal. 2002**
  - **Field application of FRP composite bars as reinforcement for bridges and decks.**

6. Use of Locally available marginal/ road building material/Industrial Waste/Municipal Solid Waste landfill for Road construction

To reduce the GHG gases emission and cost of transportation, it is suggested during DPR stage itself the locally available marginal road building material as well as industrial waste/Slag/mines waste has to be evaluated. DPR must have the recommendations regarding improvement measures to uplift locally available material/industrial/mines waste to the premium road building material in the vicinity of the Project Road.

7. Type of Concrete Pavement

7.1 Bonded Concrete Pavement

Bonded Concrete pavement shall be designed as per IRC: 58-2015 for new construction. It is similar to conventional concrete pavement except no polythene sheet in between DLC and PQC. Generally the thickness of conventional concrete pavement is 280-300mm, whereas with bonded concrete pavement it is 220-240mm. That is reduction of 20-25% PQC concrete volume and initially construction cost itself is comparable to the conventional flexible pavement.

7.2 **Short-Panelled Concrete Pavement/Geo-cell filled Concrete Pavement**

For new construction, even short-panelled concrete pavement may be considered. It is similar to conventional concrete pavement with shorter panel sizes i.e. 1.0mX1.0m, 1.5mX1.5m and 1.75mX1.75m. The design thickness may generally vary from 180-220mm.

Trial sections have been laid in some of the projects, such as Panagarh – Barwa Adda (NH-2) and Baharagora – Kharagpur section of NH-33 and are being monitored; so far generally the performance has been observed as satisfactory. IRC Guidelines for the same are under development presently.

7.3 Pre-tensioned Pre-cast Concrete Pavement (PPCP)

For construction of new concrete pavement in urban/congested locations and panel replacement of existing concrete pavement, pre-tensioned pre-cast concrete pavement (PPCP) shall be adopted. The design thickness varies from 180-200mm.It shall be designed using IRC: 58-2011 and computation of stresses should be done based on Finite Element Modelling (FEM). Sections have been laid in some of the projects, such as Nagpur Inner Ring Road, Nagpur Hingla Industrial Area, Amravati Pathan Chowk; so far generally the performance has been observed as satisfactory. IRC Guidelines for the same are under development presently.

7.4 White-Topping for Existing Flexible Pavement Rehabilitation

White-topping shall be also evaluated for rehabilitation of existing flexible pavement. Its thickness varies from 150-180mm as per IRC: SP: 76-2015.

8. Use of Geo-composite alternative to Subbase layer

Generally the thickness of subbase being use varies from 150-200mm. An alternative to this conventional subbase layer, it is better to use geo-composite. It is cost-effective and lesser use of aggregate for road construction.

9. Use of Waterproofing Membrane alternative to Mastic over Bridge Deck

Generally the thickness of mastic being used varies from 25-40mm on bridge deck. An alternative to this is 3-5mm thick water proofing membrane. It is cost-effective.

10. Utilisation/re-use of Reclaimed Road Material

10.1 Expansive Black Cotton Soil

Expansive black cotton soil is available in Maharashtra, Madhya Pradesh, Andra Pradesh, Chhattisgarh, Gujarat and Karnataka. Generally this unsuitable soil is being removed and replaced with suitable material to a minimum depth of 500mm. For the same, there is always a problem of dumping site.

It is better to improve this unsuitable soil with fly ash/pond ash/hydrated lime/cement and reuse it for earthwork. With the same, there is no requirement of suitable borrow earth as well as savings in transportation cost and reduction in GHG emission.

Therefore, suitable decision may be taken to adopt appropriate methodology based on relative scale of economy of alternate options.

10.2 Reuse of Excavated Soil

There must be accountability regarding reuse of excavated suitable soil.

10.3 Reuse of Reclaimed Existing Pavement Granular layer material

It is observed that there is a substantial generation of granular layer material while doing up-gradation/capacity augmentation/rehabilitation/submerging due to proposed VUP/PUP.

It is prudent to reclaim the same and use in subbase/base of proposed pavement. There must be accountability regarding reuse of reclaimed existing pavement granular layer material.

10.4 Reuse of Reclaimed Bituminous layer material (RAP) of existing flexible Pavement

It is observed that there is a substantial generation of existing bituminous layer material while doing up-gradation/capacity augmentation/rehabilitation/submerging due to proposed VUP/PUP/conversion of flexible to concrete pavement.

Generally it is observed that the existing bituminous layer material is dismantled and dumped along national Highway in case of reconstruction/submerging due to proposed VUP/Pup/change of pavement type to concrete pavement. It is merely a huge loss to the nation due to wastage of costly RAP. There must be a RAP bank along the National Highway.

However, in rehabilitation of existing flexible pavement it is being reclaimed through milling and being reused in DBM layer mix. The proportion of RAP is 20-30% with conventional Hot Mix Plant (batch type) with RAP attachment. It can be further increased to 60-100% with purpose-built Double barrel continuous hot mix plant.

The milled RAP is also being used as RAP layer by adding 25% virgin aggregate, 1.0% cement and 2-3% foamed bitumen/emulsion. RAP is used as bituminous base course.

Even RAP can be used for DLC of Concrete Pavement.

It is prudent to reclaim the same and re-use 100% RAP generated. There must be accountability regarding reuse of reclaimed RAP.

The guidelines to be referred are IRC: 37-2018 and IRC: 120-2015 except for % of RAP, which may be increased.

11. SUPERPAVE Method of Bituminous Mix Design Method

The Marshall method of mix design has limitations of not closely simulating the actual compaction carried out in the field. This limitation is addressed in SUPERPAVE method of bituminous mix design; this technology is expected to be beneficial for heavy traffic corridors in tandem with high ambient temperature. The technology simply requires a SUPERPAVE Gyratory Compactor. With SUPERPAVE method, there would be estimated reduction in design bitumen content to the tune of 0.2-0.3%, resulting into eventual savings. The guideline to be referred is Asphalt Institute Manual Series SUPERPAVE SP-2.

12. Amendment in Minimum Bitumen content in MORT&H Specification

The minimum bitumen content specified in MORT&H specification for Bituminous Concrete (BC) mix is 5.2% and 5.0% for grading 2 and 1 respectively. It appears to be on higher side causing pre-mature bituminous layer rutting as reported in several NH projects like Chitradurga-Hospet, Udaipur-Chittorgarh etc. It can be reduced to 4.9% and 4.7% for grading 2 and grading 1 respectively for cost estimate; no further negative tolerances for feeding into Hot Mix Plant may be considered however.

Similarly, the minimum bitumen content for design air-void 4.0% specified in MORT&H specification for Dense Graded Bituminous Mix (DBM) mix is of 4.5% and 4.0% for grading 2 and 1 respectively also appears to be on higher side and can be reduced to 4.3% and 3.8% for grading 2 and grading 1 respectively for cost estimate; no further negative tolerances

for feeding into Hot Mix Plant may be considered however. In case of design air-void 3.0% or 3.5%, the bitumen content should be increased as per the design requirement.

13. Use of High Modulus Bituminous Mix for Perpetual Pavement (PP)

Perpetual Pavement is being constructed for entire 25 packages of Delhi-Vadodara Expressways and other green-field expressways. The thickness of DBM with VG-40 bitumen is 250mm.

Presently, IRC: 37-2018 does not allow modified bitumen in DBM layer due to recyclability issue, however in PP there will not be recycle of DBM layer as only recycling/renewal of SMA wearing course is envisaged. Therefore, it is better to have high modulus DBM layer for PP. It will result into straightway **100mm reduction of DBM layer**, and thus substantial savings in initial construction cost of Perpetual Pavement.

14. Use of Fiber Reinforced Micro-surfacing for Renewal Course

Micro-surfacing is an eco-friendly treatment which is used to restore the surface characteristics of the road. If the pavement is structurally adequate, Micro-surfacing is very suitable to preserve the pavement from ageing, oxidation, aggregate loss and polishing irrespective of the traffic (i.e. suitable for low, medium, and high traffic). Fibre-reinforced Micro-surfacing is much superior to conventional Micro-surfacing. Presence of glass fibre in Fibre-reinforced Micro-surfacing helps in enhancing the flexural strength of the Micro-surfacing and thereby drastically reduces the chances of reflective cracking. There are no specifications in India for Fiber-reinforced Micro-surfacing, hence Downers Report to be reffered. Generally the doses of fiber is 0.2% by dry weight of aggregate. The guideline for conventional micro-surfacing to be referred is IRC: SP: 81.

For wearing course renewal, fiber reinforced micro-surfacing of 8-10mnm thickness shall be adopted.

15. Use of Micro-Bituminous Concrete (MBC) for Improvement in Riding Quality (IRQP) Works

A 15-20mm thick micro-bituminous concrete with 7.5mm nominal maximum size aggregate shall be adopted for IRQP works. It is similar to conventional BC Mix Design parameters and requirements except the grading shall be as per mix designation DG7 of Newzeland Transport Agency NZTA M10-2014.

16. Use of Integral Super-Structures in Major Structures

Integral structure deck super-structure, which gives continuity shall be used. Due to deck continuity, there will be reduction in deck depth, lesser number of bearings & expansion joints and hence lesser maintenance and improved rideability.

17. Use of High Damping Rubber bearing for Structures

High Damping Rubber (HDR) bearing may be used. It will also act as seismic isolators during earthquake and cost-effective. Design codes and testing procedures for such bearings are already available in some countries, as also, in CEN (2005) “Eurocode 8: Design of Structures for Earthquake Resistance – Part 2: Bridges”, pr EN 1998-2 (Final Draft), Comité Européen de Normalisation, Brussels, Belgium.

18. Use of Pre-cast Structures

Use of pre-cast for VUP/LVUP/PUP/Box Culvert shall be promoted. It will result into time savings.

19. Waste to Wealth

Pond Ash is the proven material for embankment/subgrade layer construction. Its availability shall be ensured for the construction of highways.

20. Use of Geo-cell for Slope Protection Measures

Geo-cell filled with locally available marginal material shall be an alternative to the conventional stone pitching used for slope protection measures. The guideline to be referred is IRC: 56-2011"Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control (First Revision)".

21. Use of Geo-Composite for Filter Material behind RE Wall/Retaining wall/Abutments

Geo-composite shall be used as an alternative to conventional aggregate filter material in 0.6m width behind RE wall/Retaining Wall/Abutments of structures. It will be cost-effective as well as substitute of virgin aggregate. The guideline to be referred is IRC: SP: 59-2019" Guidelines for Use of Geosynthetics in Road Pavements and Associated Works (First Revision) and section 3100 of MoRT&H Specification".

22. Use of Soil Stabilised Earthen Shoulder

Presently in upper 150mm of earthen shoulder crushed aggregate is being used. As a cost-effective alternative soil treated with 3-4% cement shall be used. It will also not require virgin aggregate. The guideline to be referred is Kenyan Pavement design Manual.

23. Use of Construction & Demolition(C&D) Waste

A C&D bank shall be along the National Highway and the material shall be used as an alternative to sand/fine aggregate for concrete. For this crushing of C&D material will be required. The guideline to be referred is IRC: 121- 2017 "Guidelines for Use of Construction and Demolition Waste in Road Sector".

24. 100% Recycling of Reclaimed Bituminous Layer Material

India has presently about 1.41 lakh km length of National Highways Network. Progress of about 37 km per day was achieved for development works on NHs during 2021-22. However, the quantum of the aged asset is increasing, which warrant rehabilitation to extend its life further. Therefore, emphasis is also required to be given for taking up rehabilitation/strengthening works on NHs. Therefore to have cost-effective and sustainable rehabilitation/strengthening, It is prudent to reclaim the bituminous layer material and reuse it 100% by adding innovative rejuvenating agents to get reclaimed bitumen properties at par with fresh bitumen.

With afore-mentioned value engineering practices (as discussed from sl. no. 01 to 24), there may be a reduction of initial project cost in the tune of **20-30 %**. Besides this, there is a time savings, less consumption of road building materials and less emission of GHG without compromising performance durability of the National Highways Asset.