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Discussions on the structure of the final report of the Expert Group

Terminology on Benchmarking Road Transport Infrastructure Construction Costs

Note by the secretariat and the road transport team of experts*

I. Mandate

1. In accordance with its Terms of Reference, the Group of Experts is expected to complete its work within two years (2016-2018) and to submit a full report of its accomplishments (ECE/TRANS/WP.5/GE.4/2016/1). The Group of Experts shall assist in:

(a) Identify models, methodologies, tools and good practices for evaluating, calculating and analysing inland transport infrastructure construction costs;

(b) Identify and list terminologies used in UNECE region for construction costs of inland transport infrastructure, if possible, create a glossary of agreed terminologies and related explanations;

(c) Collect and analyse data in order to prepare a benchmarking of transport infrastructure construction costs along the ECE region for each inland transport mode - road, rail, inland waterways - including intermodal terminals, freight/logistics centres and ports. Analyse and describe the conditions / parameters under which these costs have been calculated on.

2. In carrying out its main tasks, the Group of Experts will, among others, also identify suitable methodological approaches, models and tools for gathering and disseminating

* This document was submitted late due to delayed inputs from other sources.

information, i.e. conducting studies, distributing questionnaires, using existing studies and national strategies, existing best practices in calculating transport infrastructure construction costs, among others.

II. Terminology

3. Acquisition cost: All costs included in acquiring an asset by purchase/lease or construction procurement route, excluding costs during the occupation and use or end-of-life phases of the life cycle of the constructed asset (1).

4. Activity: A specific action performed by the highway agency or the contractor, such as initial construction or major rehabilitation. An activity is defined by its physical costs, its service life, and its effects on highway users. An activity is a component of an alternative (5).

5. Additive: Constituent material that can be added in small quantities to influence specific properties of the mixture. Note 1 to entry: For example additives are used to influence the affinity of binder to aggregate, and the mechanical properties when using inorganic and organic fibres and polymers. They are also used to influence the colour of the mixture (10).

6. Administrative Costs: Costs incurred in contract management administration overhead expenses (5).

7. Agency: A government organization responsible for initiating and carrying forward a highway program for the general public. May refer to a federal highway agency, state transportation department, metropolitan planning organization, local government organization, and so forth (5).

8. Aggregate: Granular material of natural, manufactured or recycled origin used in construction (9).

9. Aggregate Size: Designation of aggregate in terms of lower (d) and upper (D) sieve sizes expressed as d/D. Note 1 to entry: This designation accepts the presence of some particles which are retained on the upper sieve (oversize) and some which pass the lower sieve (undersize) (9).

10. Alternative contracting: Type of contract that is executed in ways other than traditional design-bid-build type (5).

11. Analysis period: The time period used for comparing pavement-type alternatives. An analysis period may contain several maintenance and rehabilitation activities during the life cycle of the pavement being evaluated. The analysis period should not be confused with the pavement design or service life (5).

12. Anionic Bituminous Emulsion: Emulsion in which the emulsifier imparts negative charges to the dispersed bitumen droplets (8).

13. Asphalt: Homogenous mixture typically of coarse and fine aggregates, filler aggregate and bituminous binder which is used in the construction of a pavement. Note 1 to entry: Asphalt can include one or more additives to enhance the laying characteristics, performance or appearance of the mixture (10).

14. Asphalt Concrete (AC): Asphalt in which the aggregate particles are continuously graded or gap-graded to form an interlocking structure (10).

15. Asphalt Concrete for very thin layers (AC-TL): Asphalt for surface courses with a thickness of 20 mm to 30 mm, in which the aggregate particles are generally gap-graded to form a stone to stone contact and to provide an open surface texture (10).

16. Asphalt for Ultra-Thin Layers (AUTL): Asphalt for Ultra-Thin Layers (AUTL) is a hot mix asphalt road surface course laid on a bonding layer, at a nominal thickness between 10 mm and 20 mm with properties suitable for the intended use. The method of bonding is an essential part of the process and the final product is a combination of the bonding system and the bituminous mixture (10).

17. Base: Main structural element of a pavement. Note 1 to entry: The base can be laid in one or more courses, described as “upper” base, “lower” base (10).

18. Binder: Material serving to adhere to aggregate and ensure cohesion of the mixture. Note 1 to entry: Any solid support may be adhered with the binder (8).

19. Binder Course: Structural part of the pavement between the surface course and the base (10).

20. Bio-Fluxed Bitumen: Bitumen whose viscosity has been reduced by the addition of a flux oil derived from vegetal or animal oils (8).

21. Bitumen: Virtually not volatile, adhesive and waterproofing material derived from crude petroleum, or present in natural asphalt, which is completely or nearly completely soluble in toluene, and very viscous or nearly solid at ambient temperatures (8).

22. Bituminous Binder: Adhesive material containing bitumen. Note 1 to entry: A bituminous binder may be in any of the following forms: unmodified, modified, oxidized, cut-back, fluxed, emulsified. Note 2 to entry: To avoid uncertainty, whenever possible the term describing the actual binder in question should be used (8).

23. Bituminous Emulsion: Emulsion in which the dispersed phase is bituminous. Note 1 to entry: Unless otherwise stated, continuous phase is assumed to be aqueous solution (8).

24. Capital Cost: Initial construction costs and costs of initial adaptation where these are treated as capital expenditure. Note 1 to entry: The capital cost may be identical to the acquisition cost if initial adaptation costs are not included (1).

25. Cationic Bituminous Emulsion: emulsion in which the emulsifier imparts positive charges to the dispersed bitumen droplets (8).

26. Coarse Aggregate: Designation given to the larger aggregate sizes with D greater than 4 mm and d greater than or equal to 1 mm(9).

27. Construction Product: Item manufactured or processed for incorporation in construction works. Note 1 to entry: Construction products are items supplied by a single responsible body. Note 2 to entry: Adapted from the definition in ISO 6707-1 according to the recommendation of ISO/TC59/AHG Terminology (2).

28. Construction Service: Activity that supports the construction process or subsequent maintenance (SOURCE: EN 15804:2012+A1:2013)(2).

29. Construction Works: Everything that is constructed or results from construction operations. Note 1 to entry: This covers both building and civil engineering works, and both structural and non-structural elements. Note 2 to entry: Adapted from the definition in ISO 6707-1 (2).

30. Construction Administration Cost: The normal cost of administration, management, reporting, design services in construction, and community outreach required in the construction phase of a project (4).

31. Construction Allowance: An amount of additional resources included in an estimate to cover the cost of known but undefined requirements for a construction activity or work item. A construction allowance is a normal cost (4).

32. Construction Contingency: An additional markup applied to cover the cost of undefined and as yet unknown construction requirements that are expected to be zero at completion of construction. Construction contingency is a risk cost (4).

33. Construction Phase: The project development phase that includes advertising the project, awarding the contract, and performing the actual construction (4).

34. Contractor: Private entity that provides design, construction, and/or maintenance services to a highway agency. May refer to the design-builder or a concessionaire (5).

35. Corrective Maintenance: Activity performed to correct deficiencies that negatively impact the safe, efficient operations of the facility, and future integrity of the pavement section. Corrective maintenance generally is reactive to unforeseen conditions to restore a pavement to an acceptable level of service(5).

36. Correlation Analysis: A statistical technique that is used to study the relationship among variables (5).

37. Cost-based Estimating: A method to estimate the bid cost of a work item by estimating the cost of resources (time, equipment, labour, and materials) for each component task necessary to complete the work item, and then adding a reasonable amount for contractor's overhead and profit (5).

38. Course: Element of a pavement constructed with a single asphalt mixture. Note 1 to entry: A course can be laid in one or more layers (10).

39. Cut-Back Bitumen: Bitumen whose viscosity has been reduced by the addition of a cut-back solvent (8).

40. Design life: The length of time for which a pavement structure is being designed based on structural distresses and traffic loadings (5).

41. Discounted cost: Resulting cost when the real cost is discounted by the real discount rate or when the nominal cost is discounted by the nominal discount rate (1).

42. Discount rate: The time value of money used as the means of comparing the alternative uses for funds by reducing the future expected costs or benefits to present-day terms. Discount rates are used to reduce various costs or benefits to their present value or to uniform annual costs so that the economics of the various alternatives can be compared (approximately equal to interest minus inflation) (5).

43. Disposal cost: Costs associated with disposal of the asset at the end of its life cycle, including taking account of any asset transfer obligations. Note 1 to entry: Asset transfer obligations could include bringing the assets up to a predefined condition. Note 2 to entry: Income from selling the asset is part of WLC[1], where the residual value of the building components, materials and appliances can be included (1).

44. Double layered Porous Asphalt (2L-PA): The top layer with a grain size 4/8 mm is about 25 mm thick and the second/bottom layer is porous asphalt with a course aggregate (11/16 mm). The total thickness is about 70 mm. Because of the finer texture at the top (that gives less tyre vibrations), it gives a better noise reduction than a single layer porous asphalt (10).

[1] Whole-Life Cost

45. Emulsion: Fluid system in which liquid droplets and/or liquid crystals are dispersed in a liquid. Note 1 to entry: Dispersion is thermodynamically metastable (8).

46. End-of-life cost: Net cost or fee for disposing of an asset at the end of its service life or interest period, including costs resulting from decommissioning, deconstruction and demolition of a building; recycling, making environmentally safe and recovery and disposal of components and materials and transport and regulatory costs (1).

47. Expansion (Capacity Improvement): Same as reconstruction and also involves the construction of additional through travel lanes beyond the work associated with reconstruction (7).

48. External costs: Costs associated with an asset that are not necessarily reflected in the transaction costs between provider and consumer and that, collectively, are referred to as externalities. Note 1 to entry: These costs may include business staffing, productivity and user costs; these can be taken into account in a LCC[2] analysis but should be explicitly identified (1).

49. Fine Aggregate: Designation given to the smaller aggregate sizes with D less than or equal to 4 mm and d = 0 (9).

50. Fines: Particle size fraction of an aggregate that passes the 0,063 mm sieve (9).

51. Flux or flux oil: Relatively involatile fluid (oil) used in the manufacture of fluxed bitumen (8).

52. Fluxed Bitumen: Bitumen whose viscosity has been reduced by the addition of flux oil(s) (8).

53. Grading: Particle size distribution expressed as the percentages by mass passing a specified set of sieves (9).

54. Hot Rolled Asphalt (HRA): Dense, gap graded bituminous mixture in which the mortar of fine aggregate, filler and high viscosity binder are major contributors to the performance of the laid material". Coated chippings (nominally single size aggregate particles with a high resistance to polishing, which are lightly coated with high viscosity binder) are always rolled into and form part of a Hot Rolled Asphalt surface course. This durable surface layer was often used as a surface layer in the United Kingdom of Great Britain and Northern Ireland (10).

55. Layer: Element of a pavement laid in a single operation (10).

56. Life Cycle: Consecutive and interlinked stages in the life of the object under consideration (2).

57. Life Cycle Cost - LCC: Cost of a civil engineering works or part of works throughout its life cycle, while fulfilling technical requirements and functional requirements (2).

58. Life-cycle cost: The total cost of ownership of a pavement section computed over the analysis period (5).

[2] Life Cycle Cost

59. Life-cycle costing: Methodology for systematic economic evaluation of life-cycle costs over a period of analysis, as defined in the agreed scope. Note 1 to entry: Life-cycle costing can address a period of analysis that covers the entire life cycle or (a) selected stage(s) or periods of interest thereof (1).

60. Life-cycle cost adjustment factor: The difference in future costs of two pavement alternatives (5).

61. Life-cycle cost analysis: An economic assessment of an item, area, system, or facility and competing design alternatives considering all significant costs of ownership over the economic life, expressed in equivalent dollars (5).

62. Maintenance: The preservation of the entire roadway, including surface, shoulders, roadsides, structures, and such traffic control devices as are necessary for its safe and efficient utilization (5).

63. Maintenance: Combination of all technical and associated administrative actions during the service life to retain a civil engineering works or an assembled system (part of works) in a state in which it can perform its required functions. Note 1 to entry: Maintenance includes cleaning, servicing, repainting, repairing, replacing parts of the construction works where needed, etc. (Construction Products Directive Guidance Paper F). Note 2 to entry: Adapted from the definition in ISO 15686-1, ISO 6707-1 and in Construction Products Directive Guidance Paper F (2).

64. Maintenance cost: Total of necessarily incurred labour, material and other related costs incurred to retain a building or its parts in a state in which it can perform its required functions. Note 1 to entry: Maintenance includes conducting corrective, responsive and preventative maintenance on constructed assets, or their parts, and includes all associated management, cleaning, servicing, repainting, repairing and replacing of parts where needed to allow the constructed asset to be used for its intended purposes (1).

65. Maintenance Treatments: Treatment activities intended to correct or preserve a roadway pavement for its safe and efficient utilization (5).

66. Manufactured Aggregate: Aggregate of mineral origin resulting from an industrial process involving thermal or other modification (9).

67. Mastic Asphalt (MA): Voidless asphalt mixtures with bitumen as a binder in which the volume of filler and binder exceeds the volume of the remaining voids in the mixed". This mixture is very durable and was often used as surface layer in certain countries (10).

68. Modified Bitumen: Bituminous binder whose rheological properties have been modified during manufacture by the use of one or more chemical agents. Note 1 to entry: In this context, "chemical agent" includes natural rubber, synthetic polymers, waxes, sulfur and certain organo-metallic compounds, but not oxygen or oxidation "catalysts" such as ferric chloride, phosphoric acid and phosphorus pentoxide. Fibres and inorganic powders ("fillers") are not considered to be bitumen modifiers. Modified bitumens may be employed "directly" or in the form of cut-backs or emulsions, or blended with (for example) natural asphalt (8).

69. Natural Asphalt: Naturally occurring mixture of bitumen and finely divided mineral matter which is found in well-defined surface deposits and which is processed to remove unwanted components such as water and vegetable matter (10).

70. Natural Aggregate: Aggregate from mineral sources that has been subjected to nothing more than mechanical processing (9).

71. Net present value: The net value of all present and future costs and benefits converted to a single point in time using a discount rate factor (5).

72. Nominal cost: Expected price that will be paid when a cost is due to be paid, including estimated changes in price due to, for example, forecast change in efficiency, inflation or deflation and technology (1).

73. Normal Cost: The most probable cost for a unit or element of the project. The normal cost represents the cost that can most reasonably be expected if no significant problems occur. The normal cost typically has small uncertainty or variance (4).

74. Operation Cost: Costs incurred in running and managing the facility or built environment, including administration support services. Note 1 to entry: Operation costs could include rent, rates, insurances, energy and other environmental/regulatory inspection costs, local taxes and charges (1).

75. Pavement Condition: A quantitative representation of pavement distress at a given point in time (5).

76. Pavement Structure: The combination of subbase, base, paving geotextiles, and surface courses placed on a subgrade to support and distribute the traffic load to the roadbed (3).

77. Pavement Preservation: A program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations (6).

78. Pavement Reconstruction: The replacement of the entire existing pavement structure by the placement of the equivalent or increased pavement structure. Reconstruction usually requires the complete removal and replacement of the existing pavement structure. Reconstruction may utilize either new or recycled materials incorporated into the materials used for the reconstruction of the complete pavement section. Reconstruction is required when a pavement has either failed or has become functionally obsolete (6).

79. Pavement Rehabilitation: Consists of "structural enhancements that extend the service life of an existing pavement and/or improve its load carrying capacity. Rehabilitation techniques include restoration treatments and structural overlays (6).

80. Pavement Replacement: Renewing of the pavement either by removing the total thickness of all layers of pavement, existing asphalt layers from an existing pavement or not, and providing a new paved surface without changing capacity or geometry of the road, i.e. without changing subgrade. The lifetime of this kind of projects is 15-20 years (7).

81. Paving Bitumen: Bitumen used to coat aggregate and/or reclaimed asphalt, mainly used in the construction and maintenance of paved surfaces and hydraulic works. Note 1 to entry: In Europe, the most-used grades of paving bitumen are defined by their needle penetration at 25°C, up to a maximum value of 900 x 0,1 mm (8).

82. Petroleum Cut-Back Bitumen: Bitumen whose viscosity has been reduced by the addition of a cut-back solvent derived from petroleum. Note 1 to entry: Typically, white spirit and kerosine are the petroleum derived fluxes employed (8).

83. Polymer-Modified Bituminous Emulsion: Emulsion in which the dispersed phase is a polymer-modified bitumen or a bitumen emulsion modified with polymer latex (8).

84. Premixed Binder: Bitumen which is blended on the site of the asphalt mixing plant, with an additive before or during the addition of the binder to the plant mixer, which in the case of a continuous plant, will be before or during the delivery of the binder to the mixing zone of the drier drum (10).

85. Preventive Maintenance: A planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity) (5).

86. Project: An undertaking to develop, implement, or construct a particular transportation enhancement at a specific location or locations (4).

87. Porous Asphalt (PA): Bituminous material with bitumen as a binder prepared so as to have a very high content of interconnected voids which allow passage of water and air in order to provide the compacted mixture with drain and noise reducing characteristics (10).

88. Real Cost: Cost expressed as a value at the base date, including estimated changes in price due to forecast changes in efficiency and technology, but excluding general price inflation or deflation (1).

89. Reconditioning: Reconditioning includes improvement of grades, curves, intersections or sight distances in order to improve road infrastructure safety or changing the subgrade to widen shoulders or to improve structural capacity in addition to resurfacing or pavement replacement. The lifetime of these projects are more than 20 years (7).

90. Reconstruction: Total replacement of pavement and subgrade of an existing road. Works include both changing the existing road centerline (vertical and horizontal) at minimum 50% of the project length and replacement all the existing pavement layers. In other words, it is the rebuilding of an existing roads' pavement and subgrade to correct road geometry, to increase road safety, to ease maintenance works and to increase preservation. Reconstruction projects lifetime is generally 20-25 years (7).

91. Recycled Aggregate: Aggregate resulting from the processing of inorganic or mineral material previously used in construction. Note 1 to Entry: Recycled aggregates can also be obtained from production residues or nonconforming products, e.g. crushed unused concrete (9).

92. Regulating Course: Course of variable thickness applied to an existing course or surface to provide the necessary profile for a further course of consistent thickness (10).

93. Rehabilitation: The act or process of returning a property to a state of utility through repair or alteration that makes possible an efficient contemporary use while preserving those portions or features of the property that are significant to the property's historical, architectural, and cultural values (4).

94. Rehabilitation: The act of restoring a pavement to a former condition (Hallin et al. 2011). - Major rehabilitation “consists of structural enhancements that both extend the service life of an existing pavement and/or improve its load-carrying capability” (AASHTO 2015). - Minor rehabilitation is nonstructural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develops in flexible pavements as a result of environmental exposure (FHWA 2 www.fhwa.dot.gov/pavement/preservation/091205.cfm) (5).

95. Remaining Service Life: Structural life remaining in the pavement at the end of analysis period (5).

96. Residual Value: Value of the in-place pavement materials less the cost to remove and process the materials for reuse (5).

97. Resurfacing: Placing a new surface of an existing road in order to service in good condition, to increase skid resistance, to seal by aiming to preserve road from negative atmospheric conditions, to increase driver comfort, to prolong pavement life, etc. The aim is not to increase the bearing capacity of pavement but to prolong service life. The lifetime of road resurfacing is nearly 5 years or less (7).

98. Resurfacing by Strengthening: Renewing of road surface with paving bituminous layers either by directly or by removing calculated depth of pavement to eliminate road deterioration in order to increase bearing capacity of road. The lifetime is nearly 5 to 15 years (7).

99. Risk: The potential impact of an uncertain condition or action on project objectives and outcomes (5).

100. Risk allocation: The process of allocating contractual obligations and risks between parties (5).

101. Restoration: The act or process of accurately recovering the form and details of a property and its setting as it appeared at a particular period of time by means of the removal of later work or by the replacement of missing earlier work (4).

102. Roadbed: The graded portion of a highway prepared as a foundation for the pavement structure and shoulders (3).

103. Routine Maintenance: Consists of work that is planned and performed on a routine basis to maintain and preserve the condition of the highway system or to respond to specific conditions and events that restore the highway system to an adequate level of service (6).

104. Salvage Value: The value (positive if a residual economic value is realized and negative if demolition costs are accrued) of competing alternatives at the end of the life cycle or analysis period. [It] typically consists of remaining service life and residual value (5).

105. Working life: Period of time after installation during which a civil engineering works or an assembled system (part of works) meets or exceeds the technical performance and functional requirements. [Source: ISO 15686-1:2011] (2).

106. Service life: The period of time from completion of construction until the structural integrity of the pavement is determined to be unacceptable and rehabilitation/replacement is required (Hallin et al. 2011) (5).

107. Soft Asphalt (SA): Mixture of aggregate and soft bitumen grades". This flexible mixture is used in the Nordic countries for secondary roads (10).

108. Stone Mastic Asphalt (SMA): Gap-graded asphalt mixture with bitumen as a binder, composed of a coarse crushed aggregate skeleton bound with a mastic mortar". This mixture is of often used as a surface layer in case high stability is needed. The surface structure also has good noise reducing properties (10).

109. Sunk costs: Costs of goods and services already incurred and/or irrevocably committed. Note 1 to entry: These are ignored in an appraisal. The opportunity costs of obtaining or continuing to tie up capital are, however, included in WLC analysis and the opportunity costs of using assets can be dealt with as costs in LCC analysis (1).

110. Subgrade: The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed (3).

111. Surface Course: The top layer or layers of a pavement structure designed to accommodate the traffic load and resist skidding, traffic abrasion, and weathering (3).

112. Technical Performance: Performance related to the capability of construction works or an assembled system (part of works), which are required or are a consequence of the requirements made either by the client, users and/or by regulations (2).

113. Technical Requirement: Type and level of technical characteristics of a construction works or an assembled system (part of works), which are required or are a consequence of the requirements made by the client, users and/or by regulations (2).

114. Whole-Life Cost: All significant and relevant initial and future costs and benefits of an asset, throughout its life cycle, while fulfilling the performance requirements (1).

115. Whole-Life Costing: Methodology for systematic economic consideration of all whole-life costs and benefits over a period of analysis, as defined in the agreed scope. Note 1 to entry: The projected costs or benefits may include external costs (including, for example, finance, business costs, income from land sale, user costs). Note 2 to entry: Whole-life costing can address a period of analysis that covers the entire life cycle or (a) selected stage(s) or periods of interest thereof. Note 3 to entry: This definition should be contrasted with that for life-cycle costing (1).

III. Reference

(1) *Draft international standard ISO/DIS 15686-5.2, (Buildings and constructed assets - Service-life planning Part 5: Life-cycle costing)*, 2016.

(2) *Sustainability of construction works - Sustainability assessment of buildings and civil engineering works - Part 5: Framework fort the assessment of sustainability performance of civil engineering works*, European standard prEN 15643-5, 2016.

(3) *Standard specifications for construction of roads and bridges on federal highway projects FP – 14*, United States Department of Transportation, Federal Highway Administration (Section 101), 2014.

(4) NCHRP report 574 (National Cooperative Highway Research Program), *Guidance for Cost Estimation and Management for Highway Projects during Planning, Programming, and Preconstruction*, 2007.

(5) NCHRP synthesis 499 (National Cooperative Highway Research Program), *Alternate Design/Alternate Bid Process for Pavement-Type Selection, A Synthesis of Highway Practice*, 2017.

(6) *Memo: Pavement Preservation Definitions - Pavement Preservation - Design & Analysis - Pavements - Federal Highway Administration*.

(7) *General directorate of Turkish highways definition*.

(8) *Bitumen and bituminous binders - Terminology*, EN 12597, May 2014.

(9) *Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas*, EN 13043, 2016.

(10) *Bituminous mixtures - Material specifications - Part 1-9*, EN 13108 series (1-9), 2016.