SECTION 9 – AGGREGATES AND GRANULAR MATERIAL
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SECTION 9 – AGGREGATES AND GRANULAR MATERIAL
DESIGN CRITERIA

9.01 SCOPE

.1 Aggregates and Granular Material section refers to the work that is unique to the specification and installation of aggregates. ***(REVISED MAY 2020)***

.2 For design criteria not specified in this section, refer to Section 8.0 – Transportation or the most current version of the Geometric Design Guide for Canadian Roads, distributed by the Transportation Association of Canada (TAC). All design criteria from the Geometric Design Guide for Canadian Roads must be approved by the City Engineer prior to design stage. ***(REVISED MAY 2020)***

9.02 MINIMUM BASE AND PAVEMENT STRENGTHS ***(REVISED MAY 2020)***

.1 The minimum standards shall be as shown. Pavement and road structure design shall be based on Benkelman Beam rebound values as outlined in the most current edition of the "Pavement Design and Management Guide", distributed by the Transportation Association of Canada. The maximum Benkelman Beam deflection tested shall be corrected for seasonal variation. If required, the minimum standards shall be increased to meet the maximum Benkelman Beam deflection. Proof of minimum strengths shall be required.

	Local	**Collector**	**Arterial and all Industrial**
Coarse Gravel Sub-base, compacted 75mm minus	250 mm	250 mm	250 mm
Crushed Gravel Base, compacted 20mm minus	100 mm	150 mm	200 mm
Hot plant-mix asphalt pavement, compacted	75 mm	100 mm	125 mm
Maximum Benkelman Beam deflection	1.5 mm	1.25 mm	0.75 mm
Minimum compaction of sub-base and base gravel	95% modified proctor	95% modified proctor	95% modified proctor

(REVISED MAY 2020)

.2 Where works are to be constructed in and/or adjacent to existing streets and existing pavements do not meet the maximum Benkelman Beam deflection or is found to have road structure that does not meet current standards, the City of Nanaimo may require its removal and replacement with new road and pavement structure to meet the current standard.

SECTION 9 – AGGREGATES AND GRANULAR MATERIAL SPECIFICATION

9.20 SCOPE

.1 This specification refers to preparations and construction of the road subgrade, sub-base, and base course. Only those products approved by the City Engineer. will be accepted for installation. ***(REVISED MAY 2020)***

9.21 TESTING

.1 The Contractor will arrange for a testing firm to carry out tests to determine whether the applicable standards and specifications have been met. Where initial testing indicates non-compliance with the specifications, additional testing shall be required. All testing shall be completed at the Contractor's expense. ***(REVISED MAY 2020)***

.2 The Contractor as directed by the Engineer shall supply specimens or samples for testing.

.3 The following tests are required at a minimum: ***(REVISED MAY 2020)***

(a) Gradation determined by washed sieve analysis must be completed on the actual material (stock pile) to be incorporated into the work. The testing shall be conducted no more than one week before the arrival of material on the job site. Further testing is required for every additional 1000 tonnes, or if more than two weeks has passed since the last test, or if the material supplier or stockpile has changed. The two weeks may be extended for stockpiles on the job site or at a secure and controlled location. Testing to be in accordance with ASTM C136/C136M and ASTM C117. ***(REVISED MAY 2020)***

(b) Determination of optimum moisture content and Modified Proctor Density (ASTM D1557) on all materials supplied to the project to be used for subgrade, sub-base and base course construction.

(c) Field moisture content and compaction determined by a minimum of one field density test of sub-base, and granular base per 500 m^2 for roads and per 50 lineal m for sidewalks, will be performed as per ASTM D6938. All backfill materials in travelled areas to be compacted to a minimum 95% modified proctor density. ***(REVISED MAY 2020)***

(d) Benkelman beam tests to be done on the prepared base only.

(e) Other aggregate property tests as per the requirements specified in Section 9.29 to Section 9.32. ***(REVISED MAY 2020)***

(f) Other testing as required by the Engineer.

.4 Proof Rolling: ***(REVISED MAY 2020)***

(a) Before proceeding further with the work, each finished layer of subgrade shall be proof rolled by receiving complete coverage using a single axle truck having an 8000 kg rear axle load and a tire pressure of 550 kPa. Benkelman Beam testing may be required in conjunction with proof rolling. Should any areas of rutting or displacement result, they shall be excavated and refilled as specified in Section 4.09A Authorized Overexcavation. If, in the opinion of the Engineer, the excavation is necessitated as a result of the Contractor's operations it will be classified as unauthorized excavation. Excavated and refilled areas shall be

retested to confirm rutting and/or displacement has been eliminated. ***(REVISED MAY 2020)***

(b) Intermediate tests will be conducted on the sub-base prior to placement of road base material, and on the road base immediately prior to paving. Results of the intermediate tests will be supplied to the Contractor as a quality control guide, but will not constitute acceptance or rejection of the work.

(c) It shall be the Contractor's responsibility to provide a single axle, dual wheel truck and driver for the tests. The truck shall be equipped with 250 x 500mm, 12-ply tires inflated to a pressure of 550 kPa. The truck shall have an 8000 kg rear axle load distribution on both wheels.

(d) Where proof rolling is likely to damage works or access is limited, determination of moisture content and Modified Proctor Density on the re-molded subgrade, sub-base and base materials shall be performed as per Section 9.21 – Testing.

.5 Benkelman Beam Testing: (REVISED MAY 2020)

(a) Prior to paving, the finished base course shall be checked by the Engineer for deflections utilizing a Benkelman Beam or other approved testing device.

(b) If the calculated deflections are in excess of the maximum Benkelman Beam deflections, as outlined in Section 9.02 – Minimum Base and Pavement Strengths, measures shall be taken to strengthen the road base and pavement structure prior to paving. Paving shall not proceed until the test results meet the minimum requirements. (REVISED MAY 2020)

9.22 DESIGN SUBGRADE CROSS SECTION

.1 Design subgrade cross section shall mean the surface of the finished subgrade upon which select granular sub-base material is to be placed.

9.23 OVERBURDEN

.1 Overburden shall mean the surface material which, in the opinion of the Engineer, is not suitable for classifying as topsoil or earth fill.

9.24 TOPSOIL

.1 Topsoil is surface material containing organic components and which, in the opinion of the Engineer, is suitable for landscaping.

9.25 STRIPPING ***(REVISED MAY 2020)***

.1 Stripping is the excavation of topsoil and overburden including the stockpiling of topsoil at a location approved by the Engineer and disposal of overburden as specified in Section 4.11 – Disposal of Excavated Material.

9.26 EARTH FILL ***(REVISED MAY 2020)***

.1 Earth fill shall include all fills comprised of common excavating containing less than 15% by volume of rock larger than 150 mm in size, free of organic and deleterious matter and frozen earth lumps and shall be approved by the Engineer prior to placement.

9.27 IMPORTED EARTH FILL ***(REVISED MAY 2020)***

.1 Imported earth fill is defined as material imported from outside the project site to meet the specifications for earth fill.

9.28 ROCK FILL

.1 Rock fill shall include all fills comprised of material containing more than 85% by volume of rock larger than 150 mm in size, free of organic and deleterious matter. Rock fill shall not contain rocks greater than 600 mm in diameter and be approved by the Engineer prior to placement.

9.29 APPROVED GRANULAR MATERIAL ***(REVISED MAY 2020)***

.1 Granular Material may be used only with the express written permission of the Engineer, and provided that it can be compacted to the requirement stated in Section 9.21 and provided that the materials also meet the following requirements: ***(REVISED MAY 2020)***

(a) Approved Granular Material shall conform to the following gradation when tested in accordance with ASTM C117 and ASTM C136. ***(REVISED MAY 2020)***

US Standard Sieve Size	Gradation Limits (Percent by Weight Passing)
75 mm	100
50 mm	70 – 100
25 mm	50 – 100
4.75 mm	22 – 100
2.36 mm	10 – 85
0.075 mm	2 - 8

(REVISED MAY 2020)

(b) Tbe used only up to the bottom of the subbase layer. ***(REVISED MAY 2020)***

(c) Free of organics and foreign matter: maximum 0.5% by mass. ***(REVISED MAY 2020)***

(d) To be placed in uniform lifts not exceeding 200 mm in loose thickness. ***(REVISED MAY 2020)***

(e) Not to be used in inclement weather. ***(REVISED MAY 2020)***

(f) In-situ moisture content to be within the range determined by the Modified Proctor Test that provides the required compaction. ***(REVISED MAY 2020)***

.2 Prior to any granular material being approved, the grain size and in-situ moisture content must be verified by washed sieve and moisture content test as per ASTM C117, ASTM C136, and ASTM D2216. ***(REVISED MAY 2020)***

.3 When in the opinion of the Engineer and City Engineer, native granular material is unsuitable for reuse, it shall be removed from the construction site and approved granular material shall be used. ***(REVISED MAY 2020)***

9.30 ROAD SUB-BASE GRAVEL COURSE

.1 Road sub-base shall be of uniform quality, crushed to size as necessary and shall consist of sound, tough, durable, highly angular, 100% mechanically crushed fragments with two or more fractured faces having a rough surface texture. It shall be free from an excess of flat or elongated particles, wood, shells, coatings of clay or any other deleterious material. Sub-Base Gravel shall conform to the following limits when tested in accordance with ASTM C117 and ASTM C136/C136M: ***(REVISED MAY 2020)***

US Standard Sieve Size	**Gradation Limits (Percent by Weight Passing)**
75 mm	100
25 mm	50 - 85
0.15 mm	0 - 15
0.075 mm	0 - 8

9.31 ROAD BASE GRAVEL COURSE

Road Base shall be of uniform quality, crushed to size as necessary and shall consist of sound, tough, durable, highly angular, 100% mechanically crushed fragments. A minimum of 50% of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one fractured face as determined by particle count. Soundness shall be tested in accordance with ASTM C88 using magnesium sulfate. Maximum weighted average losses for coarse aggregate shall be 20% and maximum losses for the fine aggregate shall be 25%. The sand equivalent when tested in accordance with ASTM D2419 shall not be less than 40. The LA Abrasion value when tested in accordance with ASTM C131/C131M shall have a maximum loss by mass of 25%. Road Base Gravel shall conform to the following limits when tested in accordance with ASTM C117 and ASTM C136/C136M: ***(REVISED MAY 2020)***

US Standard Sieve Size	Gradation Limits (Percent by Weight Passing)
19 mm	100
12.5 mm	75 - 100
9.5 mm	–60 - 90
4.75 mm	40 -70
2.36 mm	27 - 55
1.18 mm	16 - 42
0.600 mm	–8 - 30
0.300 mm	–5 - 20
0.075 mm	2 - 8

(REVISED MAY 2020)

.1 The Contractor shall submit to the Engineer for approval his proposed base course gradation for the project. Upon approval, this gradation curve shall become the project gradation. All samples of base course aggregate used on the project shall conform to the following requirements:

(a) Deviation between samples and the project gradation shall not exceed the following limits:

US Standard Sieve Size	Gradation Limits (Percent by Weight Passing)
Larger than 2.36 mm	±3.5%
1.18 mm - 2.36 mm	±3.5%
0.3 mm - 0.6 mm	±2%
0.075 mm - 0.15 mm	±1%

(REVISED MAY 2020)

9.32 RECYCLED AGGREGATE MATERIAL (RAM)

.1 Aggregates containing recycled material may be utilized up to the bottom of the sub base layer if approved by the Engineer. In addition to meeting the requirements of this specification, recycled material should not reduce the quality of construction achievable with quarried materials. RAM shall consist only of aggregates, crushed Portland cement concrete or asphalt that is free of impurities. Other construction and demolition materials such as bricks and plaster are not acceptable. The use of any recycled material must be approved by the Engineer prior to use. ***(REVISED MAY 2020)***

.2 RAM shall conform to the requirements of Section 9.30 – Road Sub-Base Gravel Course and Section 9.31 – Road Base Gravel Course, and have the following additional requirements: ***(REVISED MAY 2020)***

(a) Maximum asphalt content 1.0%. ***(REVISED MAY 2020)***
(b) Maximum percent asphalt coated aggregate not to exceed 20%. ***(REVISED MAY 2020)***
(c) Percentage (%) Loss in LA Abrasion – Coarse Aggregate: Maximum 30. ***(REVISED MAY 2020)***
(d) Soundness shall be tested in accordance with ASTM C88 using magnesium sulfate. Maximum weighted average losses for coarse aggregate shall be 20% and maximum losses for the fine aggregate shall be 25%. ***(REVISED MAY 2020)***
(e) California Bearing Ration (CBR) – Minimum 50. ***(REVISED MAY 2020)***

.3 RAM shall meet the following gradations: ***(REVISED MAY 2020)***

(a) 75 mm Minus RAM gradation shall be in accordance with Section 9.30 – Road Sub-Base Gravel Course. ***(REVISED MAY 2020)***

(b) 25 mm Minus RAM gradation shall be in accordance with Section 9.31 – Road Base Gravel Course. ***(REVISED MAY 2020)***

9.33 CLEAR CRUSH

.1 19 mm fracture shall be of uniform quality, crushed to size as necessary and shall consist of sound, tough, durable, highly angular, 100% mechanically crushed fragments with two or more fractured faces having a rough surface texture. It shall be free from an excess of flat or elongated particles, wood, shells, coatings of clay or any other deleterious material. 19 mm fracture shall conform to the following limits when tested in accordance with ASTM C117 and C136/C136M: ***(REVISED MAY 2020)***

US Standard Sieve Size	Gradation Limits (Percent by Weight Passing)
25 mm	100
19 mm	0 – 100
9.5 mm	0 – 5
4.75 m	0

9.34 PEA GRAVEL ***(REVISED MAY 2020)***

.1 Pea Gravel shall consist of round stone and shall conform to the following limits when tested in accordance with ASTM C117 and ASTM C136/C136M:

US Standard Sieve Size	Gradation Limits (Percent by Weight Passing)
9.5 mm	100
4.75 mm	50 – 100
2.36 mm	10 – 35
1.18 mm	5 – 15
0.600 mm	0 – 8
0.300 mm	0 – 5
0.150 mm	0 – 2
0.075 mm	0

SECTION 9 – AGGREGATES AND GRANULAR MATERIAL INSTALLATION

9.40 STOCKPILING ***(REVISED MAY 2020)***

.1 All aggregate materials shall be stockpiled prior to use at either the crushing site or such other location on the jobsite subject to the approval of the Engineer. Stockpile sites shall be cleared of all vegetation, trees, brush, rocks and other debris and covered with a uniform layer of pit run gravel prior to deposition of the material.

.2 Stockpiles shall be built up in layers not exceeding 1.0m in thickness to a minimum height of 3m in such a manner as to prevent any appreciable segregation. End dumping over the edge of the stockpile will not be permitted.

.3 Planks or protected runways for vehicles shall be provided as necessary to prevent contamination of the stockpile.

9.41 ROADWAY CONSTRUCTION CONDITIONS ***(REVISED MAY 2020)***

.1 Construction shall not be undertaken during snow, heavy rain, freezing, or other unsuitable conditions. Aggregate shall not be placed upon a frozen, wet, muddy or rutted subgrade or sub-base surface, unless otherwise directed by the Engineer.

9.42 STRIPPING ***(REVISED MAY 2020)***

.1 Prior to commencing excavation operation, those areas designated by the Engineer shall be stripped of all overburden and topsoil. Overburden shall be disposed of as specified in Section 4.11 – Disposal of Excavated Material. Topsoil shall be stockpiled at locations approved by the Engineer. Stumps, boulders, and other deleterious matter shall be removed from the topsoil and disposed of as specified in Section 4.11 – Disposal of Excavated Material.

9.43 SUBGRADE PREPARATION ***(REVISED MAY 2020)***

.1 In areas where, after stripping, a fill in excess of 150 mm is required to bring the finished subgrade to the design subgrade elevation, earth fill or rock fill shall be placed as specified elsewhere herein.

.2 In areas where after stripping, a cut or a fill of 150 mm or less is required to bring the finished subgrade to the design subgrade elevation, the subgrade shall be scarified to a minimum depth of 150 mm below the design subgrade elevation and all material windrowed to one side. The exposed surface shall then be compacted to 90% of Modified Proctor Density (ASTM D1557), the windrowed material moved, and the compaction repeated on the other side. Windrowed material shall then be brought to its optimum moisture content, shaped to line and grade, and compacted to 95% of Modified Proctor Density (ASTM D1557).

.3 At transitions between cut and fill areas, the subgrade in the cut area shall be scarified and recompacted as specified above to a depth of 150 mm for a distance of 20 m beyond the transition from a fill.

.4 The subgrade in cut areas shall be prepared 600 mm wider on each side than the required width of the finished base course. In fill areas, embankments shall be constructed to the required width of the finished base course as shown on the drawings with the specified side slopes. The finished subgrade shall be crowned and sloped as required to prevent ponding of water on the roadway.

.5 Soft or unstable subgrade material shall be excavated and replaced as specified in Section 4.09A – Authorized Overexcavation. If, in the opinion of the Engineer, the overexcavation is necessitated as a result of the Contractor's operations, it will be classified as unauthorized overexcavation. ***(REVISED MAY 2020)***

(REVISED MAY 2020)

9.44 WATERING FOR COMPACTION AND DUST CONTROL ***(REVISED MAY 2020)***

.1 The Contractor shall maintain suitable watering equipment on the site. Watering shall be performed as directed by the Engineer to control dust and to ensure optimum moisture conditions during compaction, determined by Modified Proctor Testing ASTM 1557 for placement of all backfill materials. ***(REVISED MAY 2020)***

.2 ***(REVISED MAY 2020)***Water shall be supplied uniformly from a pressure type distributor equipped with suitable control apparatus and a spray bar and nozzles similar to those used on asphalt distributors. Splash plate type distributors or distributors with spray bars which discharge jets or water require approval by the Engineer.

9.45 EARTH FILLS ***(REVISED MAY 2020)***

.1 Earth fills shall be constructed in such a manner that they will be completely stable at all times during construction. Silts and clays shall not be used without proper aeration and drying. Placing of frozen material in fill areas will not be permitted.

.2 Earth fills not exceeding 600 mm (compacted thickness) shall be constructed in layers not exceeding 150 mm (uncompacted thickness). Each layer shall be compacted to 95% Modified Proctor Density (ASTM D1557).

.3 Earth fills exceeding 600 mm (compacted thickness) shall be constructed in layers not exceeding 200 mm (uncompacted thickness). Each layer shall be compacted to 95% Modified Proctor Density, except the top 600 mm (compacted thickness) which shall be constructed as per Section 9.45.2. ***(REVISED MAY 2020)***

.4 Where shown on the construction drawings, or as directed by the Engineer, the existing side slopes shall be scarified or terraced to ensure proper bond between existing and fill materials. Methods shall be approved by the Engineer prior to commencing work.

.5 Should any soft spots develop during the process of compaction, such areas shall be excavated and replaced as specified in Section 4.09A – Authorized Overexcavation. If in the opinion of the Engineer, the excavation is necessitated as a result of the Contractor's operation, it will be classified as unauthorized overexcavation. ***(REVISED MAY 2020)***

9.46 ROCK FILLS ***(REVISED MAY 2020)***

.1 Rock fills shall be constructed in layers equal in thickness to the largest average size of the material, but not exceeding 600 mm. Material shall be placed and spread in such a manner that the larger rocks are well distributed and the intervening void spaces are filled with sufficient amounts of smaller rocks and fines to create a stable structure. Fill surface voids at the subgrade level to prevent migration of sub-base gravels into the rock fill.

9.47 PLACING AND COMPACTING AGGREGATES ***(REVISED MAY 2020)***

.1 The subgrade shall be approved prior to placement of the sub-base course.

.2 All aggregates and granular materials shall be approved by the Engineer prior to being delivered to the project site. Approval shall require testing as per Section 9.21 – Testing. ***(REVISED MAY 2020)***

.3 Sub-base and base course shall be placed on the approved subgrade in those locations and to the compacted thicknesses and dimensions shown on the drawings or as otherwise directed by the Engineer. Testing shall be in accordance with Section 9.21 – Testing, Section 9.49 – Proof Rolling and Section 9.50 – Benkelman Beam Testing. ***(REVISED MAY 2020)***

.4 Aggregates shall be placed in maximum 300 mm loose lifts unless otherwise specified, and shall be spread in an approved manner such that the aggregate is neither segregated nor contaminated with foreign material. Segregated materials shall be remixed until uniform. The sub-base course shall be approved prior to placement of the base course. ***(REVISED MAY 2020)***

.5 Immediately following spreading, aggregates shall be graded and compacted at optimum moisture content to 95% of Modified Proctor Density (ASTM D1557). ***(REVISED MAY 2020)***

SECTION 9 – AGGREGATES AND GRANULAR MATERIAL INSTALLATION

9.48 FINISHED GRADE ***(REVISED MAY 2020)***

.1 The finished grade surface of the compacted subgrade shall be within 15 mm of the design grade and cross section, but not uniformly high or low, when measured with a 3.0 m straightedge parallel or perpendicular to the road centreline.

.2 The finished grade surface of the compacted sub-base course shall be within 15 mm of the design grade and cross section, but not uniformly high or low, when measured with a 3.0 m straightedge parallel or perpendicular to the road centreline.

.3 The finished grade surface of the compacted base course shall be within 10mm of the design grade and cross section, but not uniformly high or low, when measured with a 3.0 m straightedge parallel or perpendicular to the road centreline.

9.49 CLEANUP ***(REVISED MAY 2020)***

.1 Prior to completion of construction, all existing and newly constructed drainage ditches, waterways, and culverts shall be cleaned to restore their full effectiveness. Boulevards and all other areas affected by the construction operation shall be cleaned of all loose rock, boulders and the debris and in all respects prepared suitable for placement of topsoil or as otherwise directed by the Engineer.

9.50 BOULEVARD GRADING ***(REVISED MAY 2020)***

.1 Boulevard areas and other areas within the road allowance or right-of-way shall be sloped, graded with 100 mm of topsoil and seeded with grass as shown on the drawings. The requirement for placement of topsoil and grass seeding shall be determined by the Engineer. As a general statement, top soil placement and grass seeding is not required in boulevards fronting undeveloped lots.