Royal Government of Cambodia

Ministry of Public Works and Transport

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Grant/Loan No. Grant No. 0285-CAM (EF) and Loan No. 3125-CAM (SF)

Flood Damage Emergency Reconstruction Project - Additional Financing (FDERP-AF)

Detailed Design and Construction Supervision

SUBPROJECT FINAL DESIGN REPORT CW14

EMERGENCY RECONSTRUCTION OF 22.00 KM OF PR2563 IN BANTEAY MEANCHEY PROVINCE

Dec 2015

In Association with

VIDO Engineering Consultant Co. Ltd.
Project Name: Flood Damage Emergency Reconstruction Project – Additional Financing
Grant No. 0285-CAM (EF) and ADB Loan No. 3125 – CAM (SF)

Report Name: Subproject Final Design Report CW14

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Date: 21/12/2015

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Abbreviations

ADB – Asian Development Bank
BME – Benefit Monitoring and Evaluation
BOQ – Bill of Quantities
CSC – Construction Supervision Consultant
DBST – Double Bitumen Surface Treatment
DDIS – Detailed Design and Implementation Services
EA – Executing Agency
EAL – Executing Assistance Loan
EIRR – Economic Internal Rate of Return
EMP – Environmental Management Plan
EMP – Environment Monitoring Plan
GDPW – General Department of Public Works
GMS – Greater Mekong Sub-region
HDM – Highway Development and Management
IA – Implementation Agency
ICB – International Competitive Bidding
IEE – Initial Environment Examination
IPC – Interim Payment Certificate
IRC – Inter-ministerial Resettlement Committee
JV – Joint Venture
MEF – Ministry of Economic and Finance
MOU – Memorandum of Understanding
MPWT – Ministry of Public Works and Transport
NCB – National Competitive Bidding
NR – National Road
PAM – Project Appraisal Manual
PCCA – Provincial Committee for the Control of AIDS
PDPWT – Provincial Department of Public Works
PPTA – Project Preparatory Technical Assistance
PR – Provincial Road
RFI – Request For Inspection
RP – Resettlement Plan
SEU – Social and Environment Unit
TOR – Terms Of Reference
VOC – Vehicle Operating Cost
Project Location Maps
Map #1: Project CW14 in Banteay Meanchey Province

GENERAL LOCATION MAP

PROVINCIAL LOCATION MAP

Grant No.:0285-CAM (EF) and Loan No.: 3125-CAM (SF)
FDERP-AF/MPWT-CW14: Subproject Final Design Report
Dec 2015
LOCATION MAP OF PR2563

22.00 Km Laterite Road on PR No.2563
1. INTRODUCTION

In Compliance with the Terms of Reference of the Consultant’s Services Agreement, this Final Design Report is prepared for the Ministry of Public Works and Transport (MPWT); the Implementing Agency for the Flood Damaged Emergency Reconstruction Project – Additional Financing (FDERP-AF).

1. Background

Starting in the third week of September 2013, Cambodia experienced heavy rainfall, serious flooding due to river overflow and flash floods, including from some areas in Thailand, which drained into Cambodia, especially in the north-western provinces of Banteay Meanchey, Battambang, Pailin and Siem Reap, where the water receded slower than expected.

The objective of the FDERP-AF Project is initially to restore critical public and social Infrastructure facilities necessary to restore livelihoods and access in the Project provinces and secondly to secure social infrastructure and services against future flooding.

One of the three components under FDERP-AF is MPWT’s responsibilities of National and Provincial Roads Rehabilitation. Under this component, MPWT is the Implementation Agency (IA) with the primary task to support and manage rehabilitation / improvement of flood damaged national and provincial roads and bridges in the following provinces: Battambang, Banteay Meanchey, Kampong Cham, Kampong Thom and Siem Reap.

Stage 2 of the restoration of flood damaged infrastructure comprise fast track repairs of Direct Contracts (DC) Projects where it is necessary to restore functionality of damaged infrastructure before the next wet season; this in order to secure the existing (undamaged) works and thus avoid more extensive damage in the coming wet season which start in June.

Stage 3 include remaining flood damage restoration to complete the remaining damage repairs, preferably within the following two dry season construction periods, with some upgrading where required.

Under Stage 2, emergency reparation works will restore the basic functionality of the infrastructure for the on-going dry and forthcoming wet season and require a minimum of detailed design. For Stage 3, the objective is to ‘build back better’ (i.e. introducing improvements and greater resilience) through improved design and construction, based on sound hydrological assessment and flood management planning including reducing the overall future flood risks.

2. Objective of the Subproject

The Objective and Scope of this Subproject is to reconstruct 22.00 km of laterite provincial road PR2563 in Banteay Meanchey province.
Table 1: Subproject CW14 which forms one of the Sub Projects in the Stage 3 works

<table>
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<td>FDERP-AF/MPWT-CW14</td>
<td>EMERGENCY RECONSTRUCTION OF 22.00 KM OF PR1570 IN BANTEAY MEANCHEY PROVINCE</td>
<td>NATIONAL COMPETITIVE BIDDING (NCB)</td>
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3. Scope of Services

Based on the FDERP-AF Fact Finding Mission in January 2014, the overall scope of the program was determined. On this basis, the Consultant provided professional engineering services for the Detailed Engineering Design of Civil Work CW14. The services included among others, a feasibility study, to economically justify the Schemes, preparation of Environmental Impact Study or Initial Environmental Examination (IEE), Environmental Management Plan (EMP), conduct of necessary, surveys and test, preparation of detailed engineering plans and specifications, cost estimates followed by bidding and contract documents after a period of detailed review of bids from a range of National Contractors.

4. Acknowledgement

The Consultant wants to thank the Design Team and the management of MPWT for their kind advice, comments and suggestions and general cooperation which have contributed significantly to the completion of the satisfactory Detailed Engineering Design of the CW14 Project and the subsequent civil works contract for CW14.

Furthermore, it is with great pleasure that we express deep appreciation to all the officers and persons of PCMU team and ADB who have significantly contributed to this Project through their assistance and cooperation with the Consultant’s team.
2. ESTABLISHMENT OF DESIGN CRITERIA

1. General

The design standard covers several factors governed by mechanical, physical, geometrical, and other laws that are interrelated. The geometric design deals with the features such as horizontal and vertical alignments, roadway sections.

2. Highway Design Standards

a. Geometric Design Standards

The geometric design standard adopted in this project is mainly established with reference to:

- A Policy on Geometric Design of Highways and Streets 2001-AASHTO.

Table 2 Geometric Design Standards for Road

<table>
<thead>
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<th>Element</th>
<th>Laterite CW14</th>
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<tbody>
<tr>
<td>1</td>
<td>Classification</td>
<td>Provincial Road</td>
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<tr>
<td>2</td>
<td>Category</td>
<td>Rural R3</td>
</tr>
<tr>
<td>3</td>
<td>Access Control</td>
<td>Non-Control</td>
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<tr>
<td>4</td>
<td>Topography</td>
<td>Flat Terrain</td>
</tr>
<tr>
<td>5</td>
<td>Design Speed</td>
<td>60 km/h</td>
</tr>
<tr>
<td>6</td>
<td>Maximum Super-elevation</td>
<td>6%</td>
</tr>
<tr>
<td>7</td>
<td>Maximum Side Friction</td>
<td>0.12</td>
</tr>
<tr>
<td>8</td>
<td>Minimum Radius of Horizontal Curve</td>
<td>160m</td>
</tr>
<tr>
<td>9</td>
<td>Minimum Transitional Length</td>
<td>50m</td>
</tr>
<tr>
<td>10</td>
<td>Minimum deflection angle for which the curve is needed</td>
<td>1.5 degree</td>
</tr>
<tr>
<td>11</td>
<td>Minimum deflection angle for which super-elevated curve is needed</td>
<td>4.0 degree</td>
</tr>
<tr>
<td>12</td>
<td>Radius for which super-elevation not required</td>
<td>≥ 1,000m</td>
</tr>
<tr>
<td>13</td>
<td>Stopping Sight Distance</td>
<td>80m</td>
</tr>
<tr>
<td>14</td>
<td>Passing Sight Distance</td>
<td>450m</td>
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<tr>
<td>15</td>
<td>Pavement Cross Fall</td>
<td>5%</td>
</tr>
<tr>
<td>16</td>
<td>Shoulder Cross Fall</td>
<td>5%</td>
</tr>
<tr>
<td>17</td>
<td>Lane Width</td>
<td>5.50m</td>
</tr>
<tr>
<td>18</td>
<td>Marginal Strip Width</td>
<td>-</td>
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<tr>
<td>19</td>
<td>Number of Lane</td>
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<td>20</td>
<td>Carriageway Width</td>
<td>11.00m</td>
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<tr>
<td>21</td>
<td>Shoulder Width</td>
<td>-</td>
</tr>
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<td>22</td>
<td>Minimum K Value for Crest Curve</td>
<td>15</td>
</tr>
<tr>
<td>23</td>
<td>Minimum K Value for Sag Curve</td>
<td>15</td>
</tr>
<tr>
<td>24</td>
<td>Maximum Grade</td>
<td>6% – 8%</td>
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b. Design Speed
Design speed is the principal criteria on which the physical features of the geometrical design is based to achieve a road design that will accommodate the traffic safely for the planned use. Once a design speed was selected, all geometric features were related to it to obtain a balanced design. For this project, physical controls were the availability of the required Right-of-Way along the established alignment.

c. Horizontal Alignment

- Horizontal Curves
The curves on roads with low traffic volume or in mountainous areas are normally designed as simple circular curves (see Figure 1). This project is considered to be a low volume traffic road.

![Simple circular curve diagram](image)

**Figure 1 Simple circular curve**
• **Horizontal Radius**
  When a vehicle moves in a circular path, it undergoes a centripetal acceleration that acts toward the center of curvature. Due to this, a minimum radius was established for safety, comfort and convenience. The minimum radius is a limiting value of curvature for a given design and was determined from the maximum rate of superelevation and the maximum side friction factor selected for design.

• **Super-elevation**
  In the design of highway curves it was necessary to establish the proper relation between design speed and curvature and their joint relations with super-elevation and side friction. The relation stems from the laws of mechanics. The basic point mass-curve formula for design and determining the minimum radius for a vehicle in operation on curve is simplified as:

\[
R_{\text{min}} = \frac{V^2}{127 \left( \frac{e_{\text{max}}}{100} + f_{\text{max}} \right)}
\]

Where:
- \( R_{\text{min}} \) = minimum radius of curve, m
- \( V \) = vehicle speed, Kph
- \( e_{\text{max}} \) = Rate of roadway superelevation, percent
- \( f_{\text{max}} \) = side friction factor

### d. Vertical Alignment

• **Sight Distances**
  The design of roads, (particularly the vertical alignment) involves the slope or gradient. Desirable gradient as specified by the Code is not always used; rather the maximum value allowed in order to minimize the construction cost, expressive realignment, Right-of-Way (R.O.W) Acquisition. As in the case of the horizontal alignment, the curved portion connecting two tangent grades is the controlling element for achieving safe design speeds on vertical alignments.

A vertical curve is considered adequate if it allows visibility such that a traveling vehicle may sight an obstruction, or another vehicle traveling in the opposite direction, with sufficient time to react in the proper manner.

In determining the required length of vertical curve the following formula is used:

\[
L_{\text{VC}} = KA
\]

Where:
- \( L_{\text{VC}} \) = Length of Vertical Curve (m)
- \( A \) = Algebraic difference of gradients (%)
- \( K \) = Rate of vertical curvature (m)

The \( K \) value is defined as the length of curve required to effect (one) 1 percent change in gradient.
- **Vertical Curves**
  For its simplicity, the vertical parabolic curve with an equivalent vertical axis centered in the vertical intersection point (PVI) is used in the design of vertical curves.

  The parabolic curves may be symmetrical when it is equally divided by the vertical axis, and unsymmetrical when is not equally divided by the vertical axis.

- **Gradients**
  The maximum gradient applied in this design is in the range of 6% - 8%.

### 3. ENGINEERING SURVEY

#### 1. Topographic Survey

a. **Surveying**
   Survey Teams by Survey Engineers through joint efforts from the Design & Supervision consultant and MPWT conducted the surveys required as a basis for the project design. The detailed topographic survey included all existing structures such as electrical posts, houses, drainage structures, bridges, river crossing, manholes and natural features such as trees, creeks, slopes, etc. All gathered information is reflected in survey drawings and Project Bid Documents.

b. **Horizontal Control**
   The horizontal position of a road with respect to established horizontal reference points establish the horizontal controls on which the alignment and the road design are based.

   Pair of base control on each project site was established by GPS techniques. Traversing is used for the short ties between GPS points. The maximum azimuth closure $10''\sqrt{N}$ (N=number of stations) or the closure ratio of 1:15,000 was attained.

   Bench marks were cemented by putty on top of concrete monuments 30 x 30 x 100 cm in size. Where the stations falls on concrete pavement/structure, cement putty was made with 2 inch nail. All points take reference to at least two or more reference points and clearly marked on permanent structures.

c. **Vertical Control**
   The vertical position of a road is established by vertical control. Datum of all elevations is Mean Sea Level (MSL) datum.

   This normal procedure was being carried out to establish the control monuments as the primary Bench Mark (BM) for the Project. Supplementary vertical controls, such as construction T-benchmarks, monument points, electric post bolts were used for the course of the entire duration of designing the project and is provided to the successful contractor.

   The primary level line is of Second Order, Class I accuracy as specified; 6mm/Km - maximum allowed loop misclosure and to ensure the accuracy of the vertical control, the double rodding-high low method was used.
The supplemental vertical controls carefully run single wire levels to meet the prescribed tolerance (8mm/km). The vertical positions of all polygon control points were also established from the Vertical Control.

d. Road Centerline Stake out
The centerline as designed and computed by the Highway Engineer was staked-out every twenty five (25) meters. In curves, additional points were also located and marked. The method used was to compute the coordinates of the centerline or ROW limits every twenty five (25) meters. The azimuth and distance of the line was then computed and this was laid out on the ground to locate the desired point.

e. Longitudinal Profile and Cross Section
All points along the centerline that were staked out and marked on the ground were levelled to obtain the ground profile of the centerline. This was done by running level lines from the nearest benchmark taking a rod reading over the point and closing back into the benchmark to determine any errors committed. An error of 20 millimetres √H is allowed for this type of levelling. The profile was plotted on millimetre paper to a scale of 1:200 V and 1:2000 H.

Profile elevations were taken on baseline stations to aid the Engineer in establishing a grade line to fit field conditions. The profile and preliminary grade line also serve as reference elevations for cross sections and the soil profiles.

Profiles are taken by differential levelling circuits beginning and ending on established benchmarks.

All profile stations have x, y, z coordinates. The corresponding station numbers were reckoned from the existing km. post and clearly painted (WHITE) on top of curb or concrete asphalt sidewalk, where these exist.

Cross section surveys at all 25 meter interval stations were generally sufficient. Closer spacing for street sections, uneven terrain or in areas where there are special drainage problems were carried out.

In general, skewed sections for drainage pipes or other special sections not required for earthwork computation were recorded separately or clearly marked as not for use in earthwork computations.

2. Geotechnical Survey

a. General
The main objectives of the geotechnical investigation are as follows:

- To determine of general sub-soil condition and its physical and mechanical characteristics of soil and materials and its classification that will compose the road alignment, pavement and embankments;
- To determine available quantity, the respective hauling distances and access road conditions of the potential material quarry sites (or borrow pits) for cost estimation and analysis.
The geotechnical/soil and material investigation works consisted of the following:

- Actual field ocular observation and inspection;
- Test pitting in-situ CBR tests and DCP tests along the road alignments;
- Investigation and field survey of available materials sources, borrow and embankment materials, aggregate materials for use of road construction project;
- Interpretation and evaluation of field testing and laboratory testing of soil sample from test pits, materials and aggregate sources;
- Determination of the factual characteristics of sub-grade soil and existing sub-base for the purpose of obtaining conclusive data to support recommendation for the pavement design and construction;
- Determination of the actual pavement condition;
- Determination of the potential materials and aggregate sources for the construction;
- Confirm the location, hauling distance and road condition of the most likely material sources to be available during construction stage;
- Confirm the available volume and quantities and classification of materials at the chosen locations.

b. Field Investigation

A total of Nine (11) test pits and eighteen (83) DCPs to a depth of 0.9m to 1.00m respectively were undertaken on a road alignment of Provincial Road PR2563 for soil profile investigations. Corresponding soil samples taken were submitted to the routine laboratory for subsequent testing.

Eleven (11) soil samples from test pits representing the strata along the stretch of the road section were submitted for routine soil classification determination. From station 0+125 to 21+050 results showed the top layer consists of silty clayey soil with reference to AASHTO classification A-4 and A-6. Specific gravity ranging from 2.65 to 2.7 while predominant in the embankment level is clay soil regarding to AASHTO classification of A-4 and, A-6 category. CBR value is ranging from 19.23% to 17.13% by CBR test in Laboratory and the DCP test results on site showed the CBR values ranging from 7.45 % to 97.41%.

A separate Geotechnical Investigation report is produced for reference (Field Survey Report - Sakor Cambodia – ref. 1580).

3. Hydrologic and Drainage Survey

For the hydrologic survey, secondary information from official sources was used. The Consultant collected and reviewed available hydrological reports and maps of the project areas including physical, geologic, and climatologic reports. A separate Hydrology Design Report provided by the design consultant from a team of hydrogeologists in 2015 is produced for reference.

4. HIGHWAY DESIGN
1. General

The roads serve important functions in Province road network. The design adopts economical and efficient design that holds down land acquisition and environmental problems.

2. Alignment Design

   a. Horizontal and Vertical Alignment

   **Horizontal Alignment**

   The horizontal alignment of road is designed to require the least possible land acquisition.

   Horizontal alignment is established based on the identified control points taking into consideration of the following main factors:
   - Residential Areas
   - Minimize if not completely possible to avoid demolition of houses.
   - Permanent Structures
   - Completely avoid demolition of existing structures.
   - Interface with Existing Roads and services

   The minimum radius used is 160m for CW14-PR2563.

   **Vertical Alignment**

   Vertical alignment was established based on the identified control points as follows:
   - Drainage Structures
     The inverted elevation level plans, the required fill cover over drainage box and pipe culverts are conformed.
   - Flood Levels
     The maximum flood levels based on the results of the hydrological analysis were considered along the project to ensure that no part of the road will be overflooded.
   - Minimum Embankment Height
     In non-flooded areas, the alignment considered the minimum embankment height in order to minimize the construction cost.
   - The k-value relative to the crest curves has been calculated in such a way as to guarantee a sight distance equal to the stopping distance in cases where the length of the vertical curve is greater than the aforesaid sight distance. The k-value regarding the sag curves has been calculated for design speed in consideration of headlight sight distance.
   - A sight distance at least equivalent to the stopping distance should be maintained along the whole length of the road. Stopping distances for level and straight conditions is 80m for laterite road.

   The minimum gradient used is respectively 0% for CW14, and the maximum gradient is respectively 7%.

   b. Super-elevation

   The maximum super elevation rate used is 6% for CW14. Normal Crown rate used is 5% for CW14.
c. **Road Traffic Facilities**
   No marking provided on laterite road CW14-PR2563.

d. **Standard Cross Section**
   The cross section of CW14-PR2563 laterite road consists of two (2) lanes per direction. Lane width is 5.50m and consist of 11.00m for carriage way, suitable for 60km/hr design speed.
Figure 2: Cross Sections

TYPICAL CROSS SECTION (1)

GENERAL SECTION, TYPE A (W=11.0m)

Top Soil

TYPICAL CROSS SECTION (2)

GENERAL SECTION, TYPE B (W=11.0m)

TYPICAL CROSS SECTION (3)

GENERAL SECTION, TYPE C (W=11.0m)

Notes:
1. All dimensions are in meters unless otherwise indicated.
2. Shoulder slope to be parallel to carriageway.
e. **Pavement Design**

Pavement design is the process of determining the thickness and strength of a pavement structure laid on a soil foundation. The main objective of the pavement design is to provide an adequate pavement structure that addresses the change in the traffic flow and loads consequent to the construction of the proposed road. The pavement design was based on the following:

- The results and findings of subgrade characteristics over which the road is to be built;
- The traffic load anticipated to traverse the proposed road alignments over the selected design life; and
- The type of pavement to be adopted based on the technical and economic advantages and available budget.

f. **Pavement Design Standard**

The pavement design type is Laterite Type for CW14-PR2563.

g. **Pavement Selection Criteria**

The criteria as to which type of pavement is adopted in the design are evaluated based on the following:

- Subsoil Condition
- Pavement Performance Against Prevailing Environmental Exposure
- Construction and Maintenance Costs
- Construction Considerations
- Safety and
- Reliability

5. **COST ESTIMATES**

1. **General**

   Price investigation and analysis is a prerequisite for estimating the unit costs of the various work items to establish unit prices for a realistic cost estimate of this project.

2. **Data Collection**

   Statistical data compiled from previous projects of FDERP and FDERP-AF were reviewed, studied and used as guiding reference in the preparation of unit price analysis for this project.

3. **Quantity Calculations**

   The quantity of each pay item on the Bill of Quantities has been calculated in accordance with the specification units and method of measurement, accordingly shown in the Volume I of "Quantity Calculation".

4. **Construction Cost Estimate**

   Construction cost of each project was estimated by using the unit prices analysed and the quantities described above as best and current references.
The cost estimate described above with the summary of cost and total project cost is compiled in the “Confidential Cost Estimate”.

6. PREPARATION OF TENDER DOCUMENT

1. General

Bidding Documents have been prepared making close reference to the following documents:

- Bidding Documents Under ADB Procurement Guideline, April 2010;
- Sub-decree No. 74 ANK. BK or otherwise known as Standard Operating Procedures (SOP) and Procurement Manual (PM) Vol.1, Royal Government of Cambodia, May 2012 Updated version

The Bidding Documents consist of the following:

Section I - Instructions to Bidders
Section II - Bid Data Sheet
Section III - General Conditions of Contract
Section IV - Special Conditions of Contract
Section V - Specifications and Performance Requirements
Section VI - Drawings
Section VII - Bill of Quantities
Section VIII - Forms of Bids, Qualifications Information, Letter of Acceptance and Agreement
Section IX - Security Forms
Section X - Mine & UXO Clearance Guideline

2. Procurement Procedure

Under Stage 3 a “Procurement” approach with selection of contractors from Public Tender announcement and NCB (National Competitive Bidding) for this project was followed. This approach with an accelerated assessment of the tenders was necessary, based on time constraint for early implementation of the Flood Damage Emergency Reconstruction Project – Additional Financing (FDERP-AF). With the urgency to commence project repairs quickly MPWT and ADB decided to tender and award these projects to start as early as possible under auspices of the Emergency Program.
ANNEX I – DRAWINGS
Annex I – Drawing “Plan and Profile”
PLAN AND PROFILE (PR2563-8)
(STA. 4+900.000 ~ 5+600.000)
Annex I – Drawing Sample of “Cross Sections”
ANNEX II – SPECIFICATION

(Please refer to Bid Document CW14 in Section V - .)
ANNEX III – COST ESTIMATES
Annex III – Cost Estimates

### Summary of Bills of Quantities

#### Grand Summary

Type of work: Emergency Reconstruction of 22.00 Km Laterite Road of PR2563 in Banteay Meanchey Province

Contract No : FDERP-AF-MPWT-CW14 (Laterite W=11.00m, L=22.00Km ; & Structure Works) - 16 Months

As of 10-July-2015

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<thead>
<tr>
<th>Bill No.</th>
<th>General Summary</th>
<th>Calculated Amount</th>
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<tr>
<td>1</td>
<td>General</td>
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<tr>
<td>2</td>
<td>Earth Works and Aliens Activities</td>
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<td>3</td>
<td>Sub-base and Base Course</td>
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<td>4</td>
<td>Pavement (Bituminous) Works</td>
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<td>5</td>
<td>Structures</td>
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<td>6</td>
<td>Drainage and Protection Works</td>
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<td>Ancillary Works</td>
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<td>8</td>
<td>Unexploded Ordnance</td>
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<td>9</td>
<td>Miscellaneous</td>
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<td>10</td>
<td>Dayworks All (Provisional Sum)</td>
<td>30,000.00</td>
</tr>
</tbody>
</table>

(A) Sub-Total of Bills = 3,418,007.68
(B) Specified Provisional Sums = 42,400.00
(C) Total of Bills = (A - B) = 3,375,607.68
(D) Contingency Allowance (10%) = (C*10%) = 337,560.77
(E) Bid Price (A + D) (Carried forward to Form of Bid) = 3,755,568.45