

ANNEX E: TRANSMISSION TOWER DETAILS

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01/2



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Lattice Tower Erection Sketches

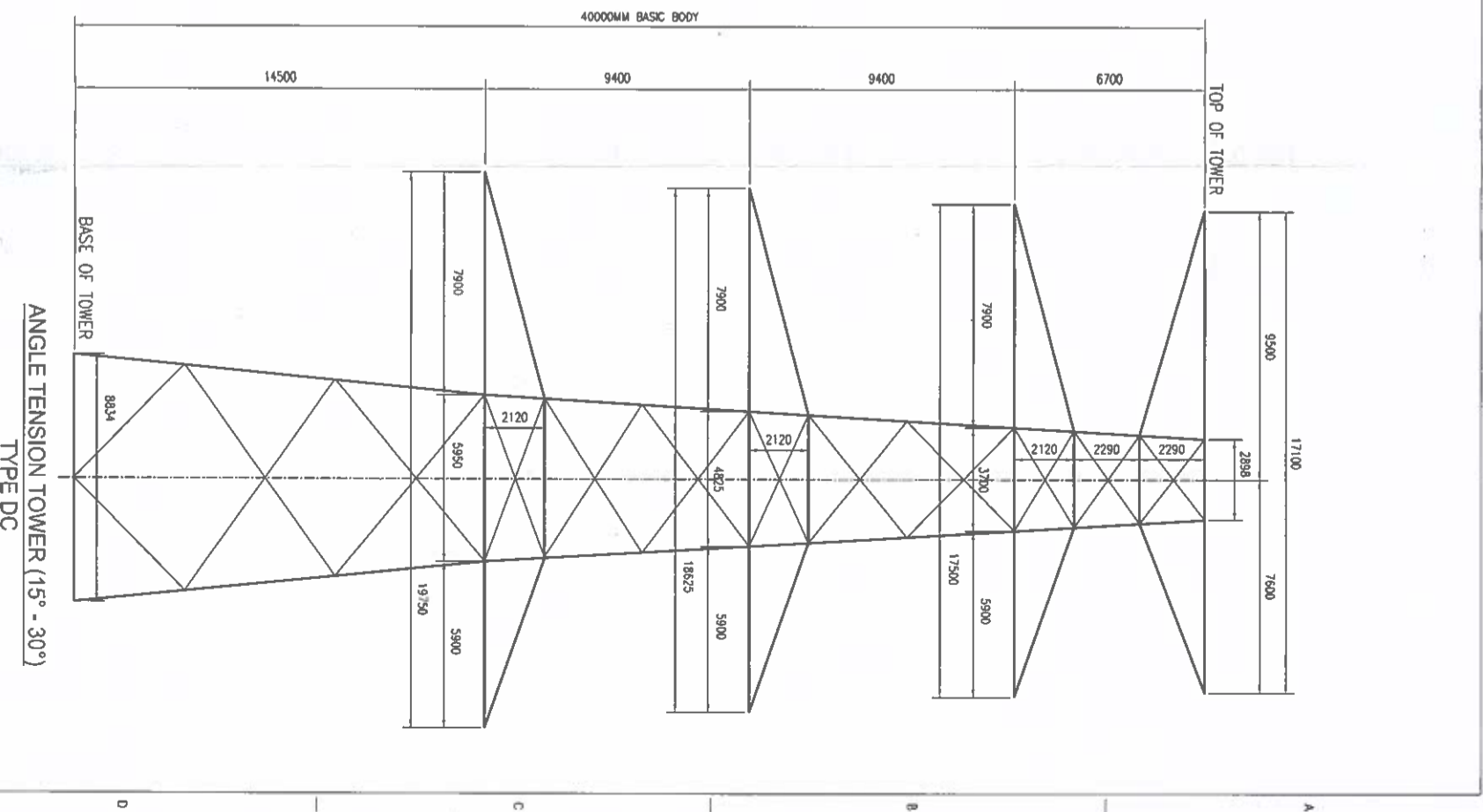
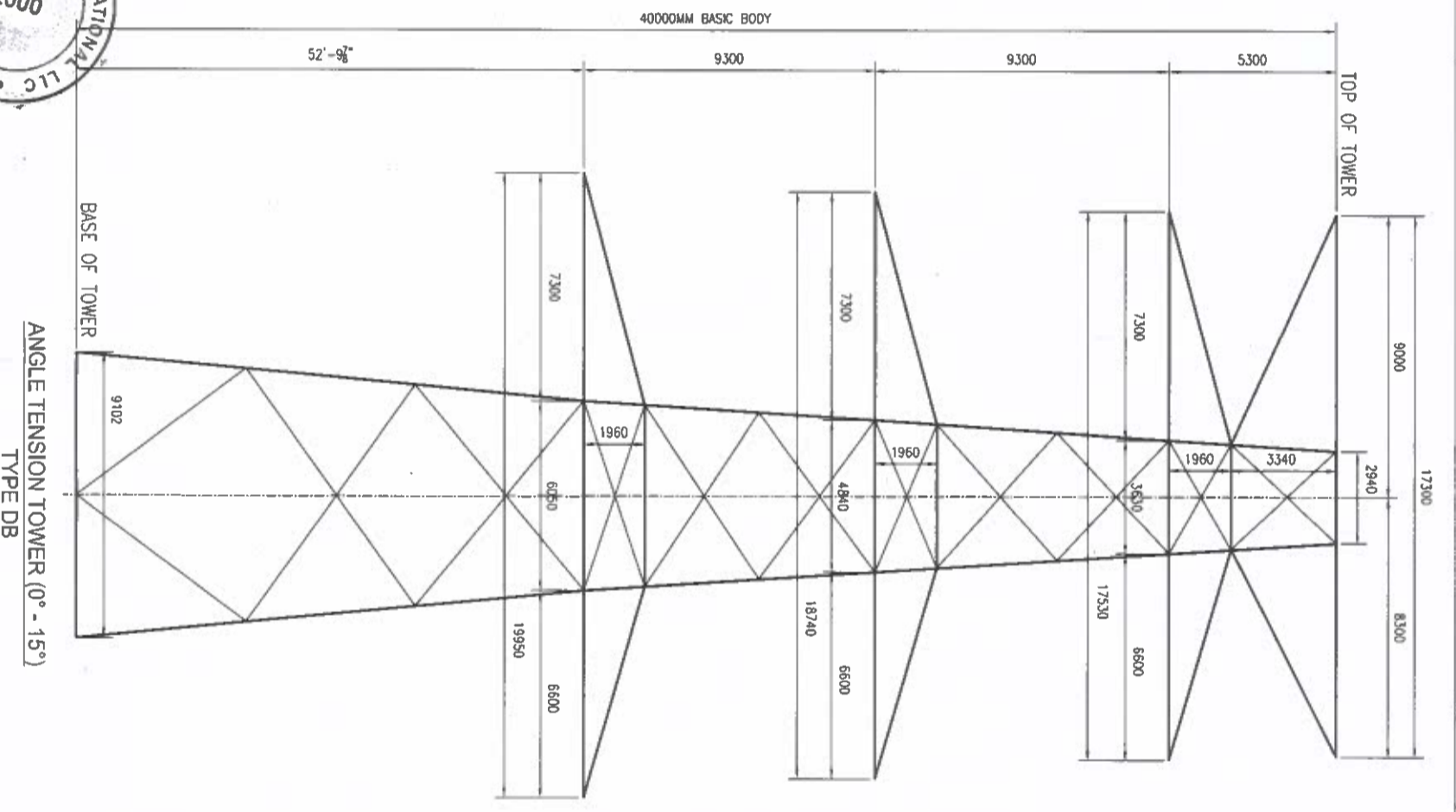
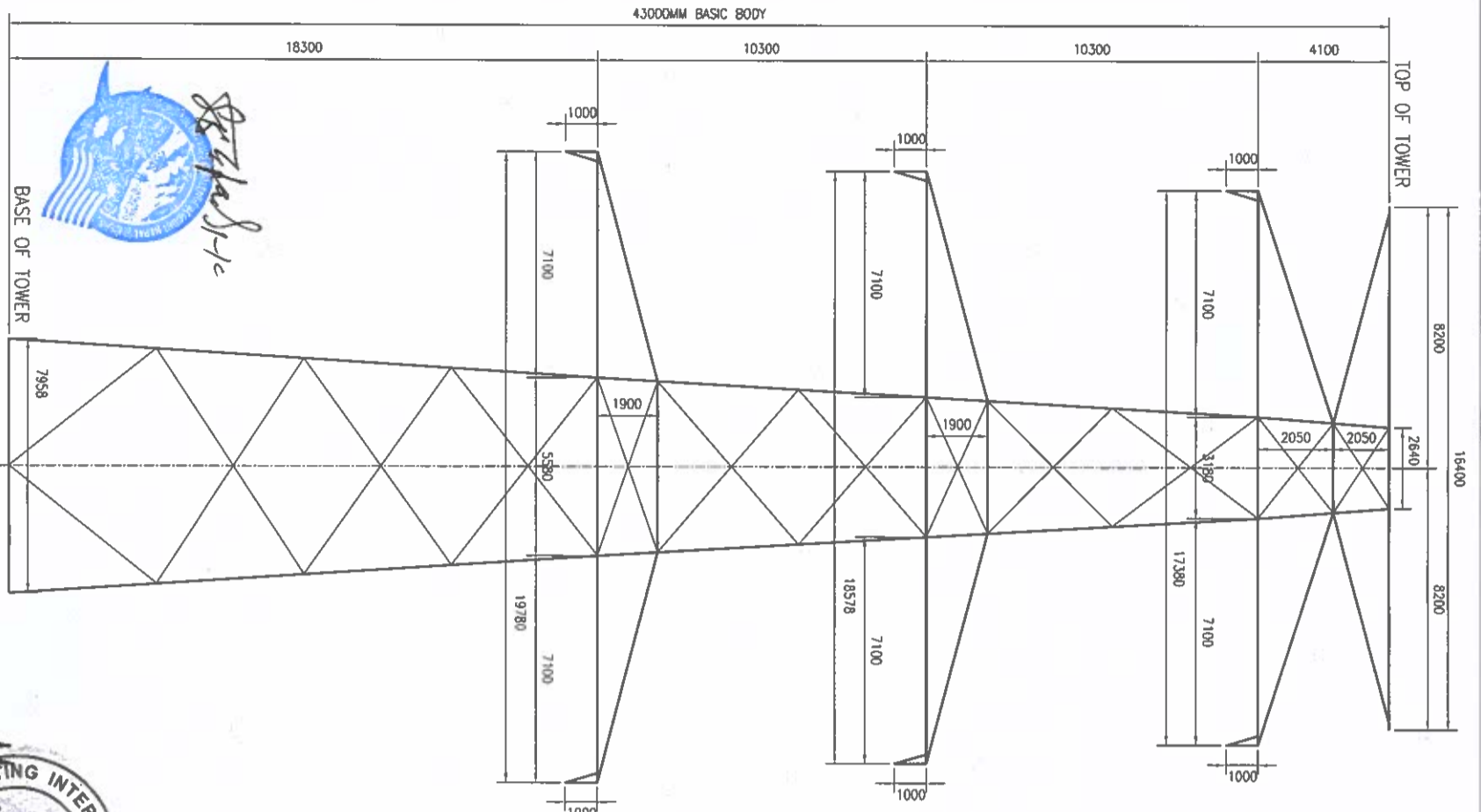
Signature



नेपाल सरकार
वन तथा वातावरण मन्त्रालय
सिंहदरबार, काठमाडौं

Signature





TANGENT SUSPENSION TOWER (0° - 2°)
TYPE DA

ANGLE TENSION TOWER (0° - 15°)
TYPE DB

ANGLE TENSION TOWER (15° - 30°)
TYPE DC

NOTE: ALL DIMENSIONS ARE IN MILLIMETERS.
PRELIMINARY DESIGN. EPC CONTRACTOR TO PROVIDE THE FINAL DESIGN FOR CONSTRUCTION

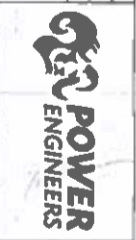


TWR-ER-1.DWG

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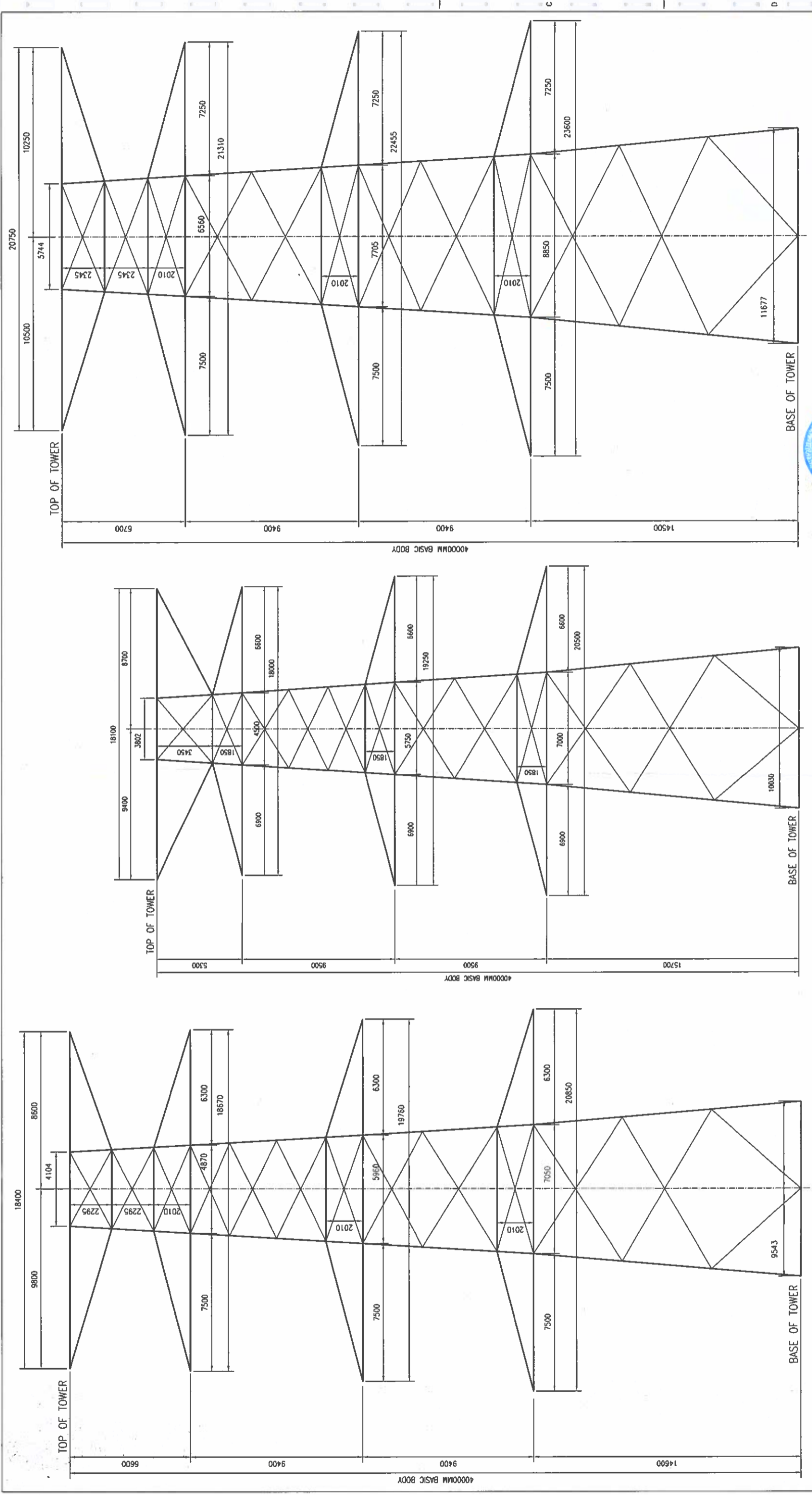
REV	ISSUED FOR	REVISIONS	DATE	DRN	CM	DSCH	CMO	APPD	REFERENCE DRAWINGS
0	ISSUED FOR BID		7-12-19	DVV	CM	DSCH	CMO	APPD	

DESIGN	DATE	SCALE
DRN	6-10-19	N.T.S.
CMO	6-10-19	
DSCH	6-10-19	



MILLENNIUM CHALLENGE ACCOUNT (MCA) - NEPAL
400KV TRANSMISSION LINE
DOUBLE CIRCUIT LINE
LATTICE TOWER ERECTION SKETCH
TOWER DA, TOWER DB & TOWER DC

JOB NUMBER	DRAWING NUMBER
153312	TWR-ER-1



ANGLE TENSION TOWER (30° - 60°)
TYPE DD

DEADEND TENSION TOWER (0° - 30°)
TYPE DE

DEADEND TENSION TOWER (30° - 90°)
TYPE DF

NOTE: ALL DIMENSIONS ARE IN MILLIMETERS.

<p>THE DRAWING WAS PREPARED BY POWER ENGINEERS INC. FOR A SPECIFIC PROJECT AND IS NOT TO BE REPRODUCED OR USED FOR ANY OTHER PROJECT WITHOUT THE WRITTEN PERMISSION OF POWER ENGINEERS INC. THIS DRAWING IS FOR INFORMATION PURPOSES ONLY. IT IS NOT TO BE USED FOR ANY PURPOSES WITHOUT THE WRITTEN PERMISSION OF POWER ENGINEERS INC.</p>		<p>POWER ENGINEERS POWER ENGINEERS PVT. LTD.</p>		<p>MILLENNIUM CHALLENGE ACCOUNT (MCA) - NEPAL RURAL TRANSMISSION LINE DOUBLE CIRCUIT LINE</p>		<p>JOB NUMBER 15312</p>		<p>REV 0</p>	
DSGN	CIMPEI	6-10-19	DRN	DYWFPEI	6-10-19	CHK	CIMPEI	6-10-19	DRAWING NUMBER TWR-ER-2
SCALE:	N.T.S.		ISSUED FOR BID	DATE	7-12-19	DIV	CM	CM	REVISIONS
REV	0	ISSUED FOR BID	DATE	7-12-19	DIV	CM	CM	CM	APPD
REFERENCE DRAWINGS		DGN		DRN		CHK		APPD	



Shree Krishna Sharma



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E - 2

Tower Characteristics Table



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Main data table with columns: Tower No, Tower Type, Tower Height (m), Line Angle (deg), Foundation (m2), Ahead Span (m), Marker Btln Ahead Span, AP/Centre (Northing, Easting, Elevation), AP/Centre (Longitude, Latitude), District, Municipality, Ward, Ownership, Existing Land Use, Distance to Nearest, Forest Community, Forest Density, Forest Mt (CZ/HA), Construction Access, Existing Trail Length, Proposed Trail Length, Total Trail Length.



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Tower No	Tower Type	Tower Height (m)	Line Angle (deg)	Foundation (m)	Ahead Span (m)	Number of Marker Galls in Ahead Span	A/P Centre (feet ppg/bm)			A/P Centre (feet ppg/bm)		District	Municipality	Ward	Ownership public/private	Existing Land Use	Distance to Closest Residence	Forest Characteristics		Forest Age (yr)	Construction Access	Construction Characteristics	
							Easting	Northing	Elevation	Longitude	Latitude							Forest Community	Forest Density			Existing Trail length (km)	Proposed Trail length (km)
226	D1B	84.5	-5.3	484	307	0	301576.15	3082726.40	674.50					5	Private	Agriculture	141.17	Forest Patch under 0.5 ha		Vehicle plus Trail	0.13	0.13	
227	D1B	83.5	-9.6	841	272	0	301827.46	3082750.23	618.99					5	Private	Forest	43.77	Forest Patch under 0.5 ha		Vehicle plus Trail	0.23	0.23	
228	D1B	71.5	-4.4	676	302	0	302145.89	3082816.32	564.00					5	Private	Forest	30.71	Forest Patch under 0.5 ha		Vehicle plus Trail	0.39	0.39	
229	D1B	66.5	-11.4	625	397	0	302431.99	3082911.89	548.89					2	Private	Forest	64.61	Forest Patch under 0.5 ha		Vehicle plus Trail	0.07	0.07	
230	D1C	66.5	11.4	641	273	3	302776.54	3083109.90	619.81					2	Public	Agriculture	79.59	Forest Patch under 0.5 ha		Vehicle plus Trail	0.15	0.15	
231	D1B	62.5	8.8	576	408	4	303059.24	3083102.64	627.69					2	Private	Road	74.24			Vehicle plus Trail	0.02	0.02	
232	D1B	62.5	-10.3	625	423	5	303405.11	3083029.19	674.08					2	Private	Agriculture	221.84			Vehicle plus Trail	0.43	0.43	
233	D1C	60.5	20.0	676	399	0	303874.69	3082826.09	674.58					2	Private	Agriculture	176.53			Vehicle plus Trail	0.12	0.12	
234	D1C	54.5	-4.8	729	237	0	304217.64	3082826.09	774.20					2	Private	Agriculture	44.64			Vehicle plus Trail	0.21	0.21	
235	D1C	52	20.0	625	720	9	304545.00	3082866.54	645.48					2	Private	Agriculture	95.95			Vehicle plus Trail	0.01	0.01	
236	D1C	54.5	-4.8	729	651	8	305164.00	3082866.54	634.48					4	Public	Forest	198.92	Tropical Silt Forest		Vehicle plus Trail	0.04	0.04	
237	D1C	52	20.0	625	651	8	305609.24	3082749.21	613.30					4	Public	Forest	220.92	Tropical Silt Forest		Vehicle plus Trail	0.47	0.47	
238	D1C	71.5	4.3	961	330	0	306079.24	3082749.21	513.35					4	Public	Forest	111.31	Tropical Silt Forest		Vehicle plus Trail	0.29	0.29	
239	D1C	74.5	16.5	900	438	0	306679.24	3082749.21	446.95					4	Private	Barren	147.98			Vehicle plus Trail	0.30	0.30	
240	D1C	50	66.3	625	332	0	306825.39	3082600.95	446.95					4	Private	Agriculture	148.75			Vehicle plus Trail	0.07	0.07	
241	D1C	56	-35.1	676	197	0	306820.28	3082112.27	480.79					7	Public	Forest	101.83	Tropical Silt Forest		Vehicle plus Trail	0.10	0.10	
242	D1A	57.5	-1.8	779	289	0	306490.37	3081915.88	480.32					7	Public	Forest	76.21	Forest Patch under 0.5 ha		Vehicle plus Trail	0.07	0.07	
243	D1B	62.5	-1.8	576	324	0	306852.96	3081951.61	480.99					7	Public	Forest	279.89	Tropical Silt Forest		Vehicle plus Trail	0.51	0.51	
244	D1C	55	-9.5	484	275	0	306852.96	3081951.40	500.49					7	Public	Forest	186.88	Tropical Silt Forest		Vehicle plus Trail	0.31	0.31	
245	D1C	59	34.4	779	233	0	307196.69	3081982.11	474.14					7	Public	Forest	83.04			Vehicle plus Trail	0.09	0.09	
246	D1C	57.5	-30.5	779	71	0	307518.62	3082020.97	480.85					7	Public	Forest	83.04			Vehicle plus Trail	0.05	0.05	
247	D1C	58		779	155	0	307787.32	3082098.55	480.85					7	Public	Forest	83.04			Vehicle plus Trail	0.12	0.12	
248	D1C	52		779	85	0	307911.53	3082001.19	482.78					7	Public	Road	31.96			Vehicle plus Trail	0.01	0.01	
249	ABDOM	22.5	0.0		0	0								7	Public	Road	31.96			Vehicle plus Trail	0.01	0.01	

दादा राव

गण संरक्षण
तांदुली
श.र. कार्यालय

श्रीकांत



Table with 26 columns: New Towers to Be Proposed Tower No., Tower Type, Tower Height (m), Line Angle (Deg), Foundation Footprint (m2), Allowed Span (m), Number of Market Bays in Allowed Span, A7/Centre (Euler Height) Easting, Northing, Elevation, A7/Centre (per georeferenced) Longitude, Latitude, District, Municipality, Ward, Social Characteristics Ownership, Existing Land Use, Distance to Closest Residence, Forest Characteristics Forest Community, Forest Density, Forest Mgt (CF/LUS), Construction Access Construction Length, Tower Height Length.

बोकारो विकास प्राधिकरण
राष्ट्रिय स्तरका कार्यालय



Signature





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E - 3

Aviation Marker Ball Placement Rationale

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Rationale	Description
CAAN Request	Civil Aviation Authority of Nepal requested Marker Balls to be placed in this location in a prior meeting.
High span	Parts of the span are over 90m above ground due to the terrain. The structure heights are not over 90m above ground.
High span over valley	Span is 90m above ground crossing over a valley.
High span over river valley	Span is 90m above ground crossing over a river valley

Span	Aviation Marker Ball Placement
India Border to New Butwal Substation	
38-39	CAAN Request
39-40	CAAN Request
40-41	CAAN Request
41-42	CAAN Request

Span	Aviation Marker Ball Placement
New Butwal to New Damauli Substation	
41-42	High span
42-43	High span
43-44	High span
44-45	High span
45-46	High span
47-48	High span over valley
77-78	High span over river valley
80-81	High span over valley
84-85	High span
86-87	High span
87-88	High span
89-90	High span
90-91	High span over valley
91-92	High span over valley
93-94	High span
96-97	High span
99-100	High span
100-101	High span
102-103	High span
103-104	High span
108-109	High span over river valley
112-113	High span
114-115	High span
115-116	High span
119-120	High span
120-121	High span
122-123	High span
126-127	High span
130-131	High span
136-137	High span
138-139	High span
139-140	High span
143-144	High span
152-153	High span
160-161	High span
164-165	High span
167-168	High span
168-169	High span
171-172	High span
174-175	High span
176-177	High span
184-185	High span
189-190	High span
200-201	High span
208-209	High span
209-210	High span
211-212	High span
212-213	High span
216-217	High span
219-220	High span
220-221	High span
221-222	High span
224-225	High span
225-226	High span
228-229	High span
233-234	High span over river valley
237-238	High span

Span	Aviation Marker Ball Placement
New Damauli to Ratmate	
8-9	High span
17-18	High span
19-20	High span
24-25	High span
43-44	High span
46-47	High span
49-50	High span
59-60	High span
60-61	High span
61-62	High span
62-63	High span
66-67	High span
94-95	High span over river valley
97-98	High span over valley
98-99	High span over valley
101-102	High span
108-109	High span over valley
110-111	High span
111-112	High span
113-114	High span
114-115	High span
116-117	High span
118-119	High span
119-120	High span
126-127	High span over valley
138-139	High span over river valley
142-143	High span
147-148	High span
148-149	High span
155-156	High span over valley
156-157	High span
160-161	High span
165-166	High span
172-173	High span
183-184	High span
188-189	High span
189-190	High span
191-192	High span
193-194	High span
201-202	High span
210-211	High span
223-224	High span
224-225	High span
230-231	High span
231-232	High span
232-233	High span
235-236	High span
236-237	High span
238-239	High span over river valley



Span	Aviation Marker Ball Placement
Ratmate to New Hetauda	
4-5	High span
8-9	High span
13-14	High span
16-17	High span
19-20	High span
20-21	High span
22-23	High span
24-25	High span over river valley
25-26	High span
27-28	High span
28-29	High span
29-30	High span
30-31	High span
31-32	High span
33-34	High span
34-35	High span
35-36	High span
39-40	High span
40-41	High span
41-42	High span
45-46	High span
46-47	High span
47-48	High span
49-50	High span
52-53	High span
56-57	High span
57-58	High span
59-60	High span
63-64	High span
64-65	High span
65-66	High span
68-69	High span over valley
70-71	High span over valley
74-75	High span
77-78	High span
78-79	High span
82-83	High span
83-84	High span
84-85	High span
85-86	High span
86-87	High span over river valley
90-91	High span
91-92	High span
93-94	High span
94-95	High span
96-97	High span
97-98	High span
98-99	High span
99-100	High span
100-101	High span
101-102	High span
105-106	High span
107-108	High span
108-109	High span
109-110	High span
112-113	High span
116-117	High span
119-120	High span
120-121	High span
126-127	High span
127-128	High span
128-129	High span
129-130	High span
130-131	High span
131-132	High span
132-133	High span

Span	Aviation Marker Ball Placement
Ratmate to Lapsihedi	
8-9	High span
9-10	High span
13-14	High span over valley
15-16	High span
16-17	High span
17-18	High span
19-20	High span
20-21	High span
24-25	High span
25-26	High span
35-36	High span
36-37	High span
37-38	High span
47-48	High span
49-50	High span
50-51	High span
51-52	High span
52-53	High span
53-54	High span
60-61	High span
64-65	High span
65-66	High span
73-74	High span
82-83	High span over river valley
86-87	High span
87-88	High span
92-93	High span
98-99	High span
99-100	High span
101-102	High span
102-103	High span
104-105	High span
108-109	High span
109-110	High span
112-113	High span
113-114	High span
116-117	High span over valley
125-126	High span
127-128	High span
128-129	High span
129-130	High span
134-135	High span
135-136	High span
136-137	High span
139-140	High span
140-141	High span
141-142	High span
142-143	High span
144-145	High span
146-147	High span
149-150	High span over valley
153-154	High span over valley
154-155	High span over valley
157-158	High span

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E - 4

Design of Marker Balls





A. Design of Marker Balls (Aircraft Warning Spheres)

- a. Nepal's Civil Aviation Authority (CAA) was contacted regarding construction of the proposed double circuit 400kV Lapsephedi – Ratmate – New Hetauda – New Damauli – New Butwal – Indian Border transmission line. A written response was received from the ATM Department providing comments. Letter number 075/76 is included as Attachment #1 for reference.

The CAA requested that wire not be strung directly from one hill to another hill, unless red marker balls are installed on the top-most wire of the transmission line.

To develop more specific guidelines, PPTS has simplified this direction by providing a maximum wire height above ground which, when exceeded, requires marker balls to be installed on the top-most wire. This eliminates the need to define "hill", as some areas are ambiguous regarding when a high spot is considered a hill, ridge, knoll, etc.

- b. The primary consideration in determining the appropriate height above which lines should be marked deals with protecting aircraft from potential collisions with the transmission line. There are several factors that contribute to how likely it is an aircraft could collide with a line. Some of these are listed below:
- 1) Wire height above ground. Typically, the higher a wire is above ground, the more likely it is that an aircraft could make contact.
 - 2) Features surrounding the line. Typically, more open air space around a line means it is more likely that an aircraft could make contact. Conversely, if there are features (trees, buildings, ridgelines, etc.) surrounding the transmission line that prevent aircraft from flying at lower elevations, the line is essentially shielded and the chances of collision are greatly reduced.

In considering point 1 above, PPTS referenced the United States' FAA Advisory Circular AC No. 70/7460-IL, which recommends that lines > 61 m (200 ft) above ground be marked for aircraft visibility. This direction provides a baseline that can be used as a starting point.

The hill regions in Nepal being traversed by the proposed line are generally forested. These trees essentially raise the effective ground height, as aircraft cannot fly below the trees.

Additionally, the terrain itself does not lend itself to low flying aircraft, as there are numerous hills and ridges that exceed 70 m in height.



Because of these factors, a height of 90 m above the ground will be used as the cutoff limit to determine when marker balls are required. Wherever the maximum wire height is < 90 m, no marker balls shall be required. For maximum wires > 90 m, the top OHGW and OPGW shall be marked according to the direction provided below:

- c. Marker balls will be evenly spaced along the OHGW/ OPGW at maximum 61 m (200 ft) intervals.
- d. Marker balls should alternate on OHGW and OPGW and be aviation red in color.
- e. Marker balls will be made of aluminum (preferable), or fiberglass.
- f. The marker balls should be EHV (Extra High Voltage) qualified, with a special coating to reduce corona effects that can degrade or discolor a standard marker ball, or even lead to burning or melting.
- g. The marker balls will use spiral formed armor rods to attach to the OHGW/ OPGW.
- h. The spiral formed armor rods will extend outward from the marker ball and reinforce and protect the OHGW/ OPGW at the point of attachment.
- i. The spiral formed armor rods will be completely slip-proof, and also prevent damage to the OHGW / OPGW.
- j. The spiral formed armor rods will be matched at the time of order to the specific size, type, and diameter of the OHGW/ OPGW.
- k. Marker balls will have minimum diameter=0.915 mm (36"), and a typical weight of 9 kg (20 lbs) without armor rods.

The marker balls will be modeled as concentrated loads in PLS-CADD software with diameter=0.915 mm (36") and weight=9 kg (20 lbs). The software will calculate the localized vertical load from radial ice thickness built on the top of the spherical marker ball and the transverse load for cases with wind alone, or wind+ice.

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E - 5

Catenary Marker Ball Spacing

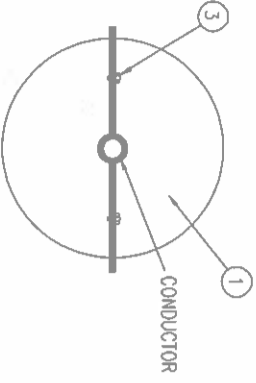
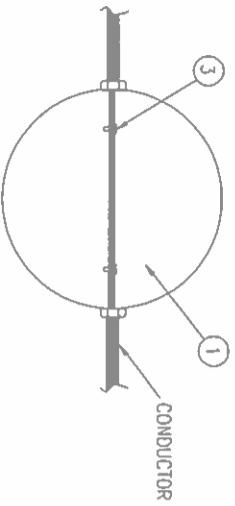
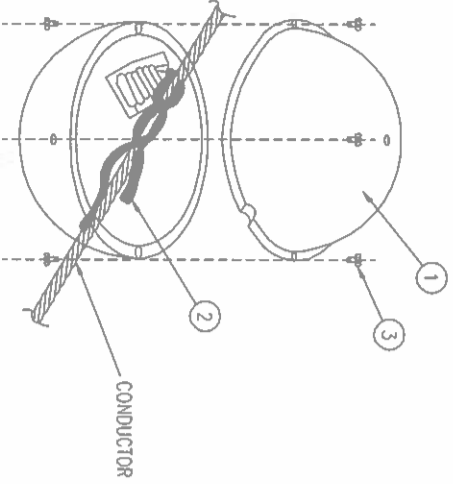
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MARKER BALL
OHGW
(OPGW)

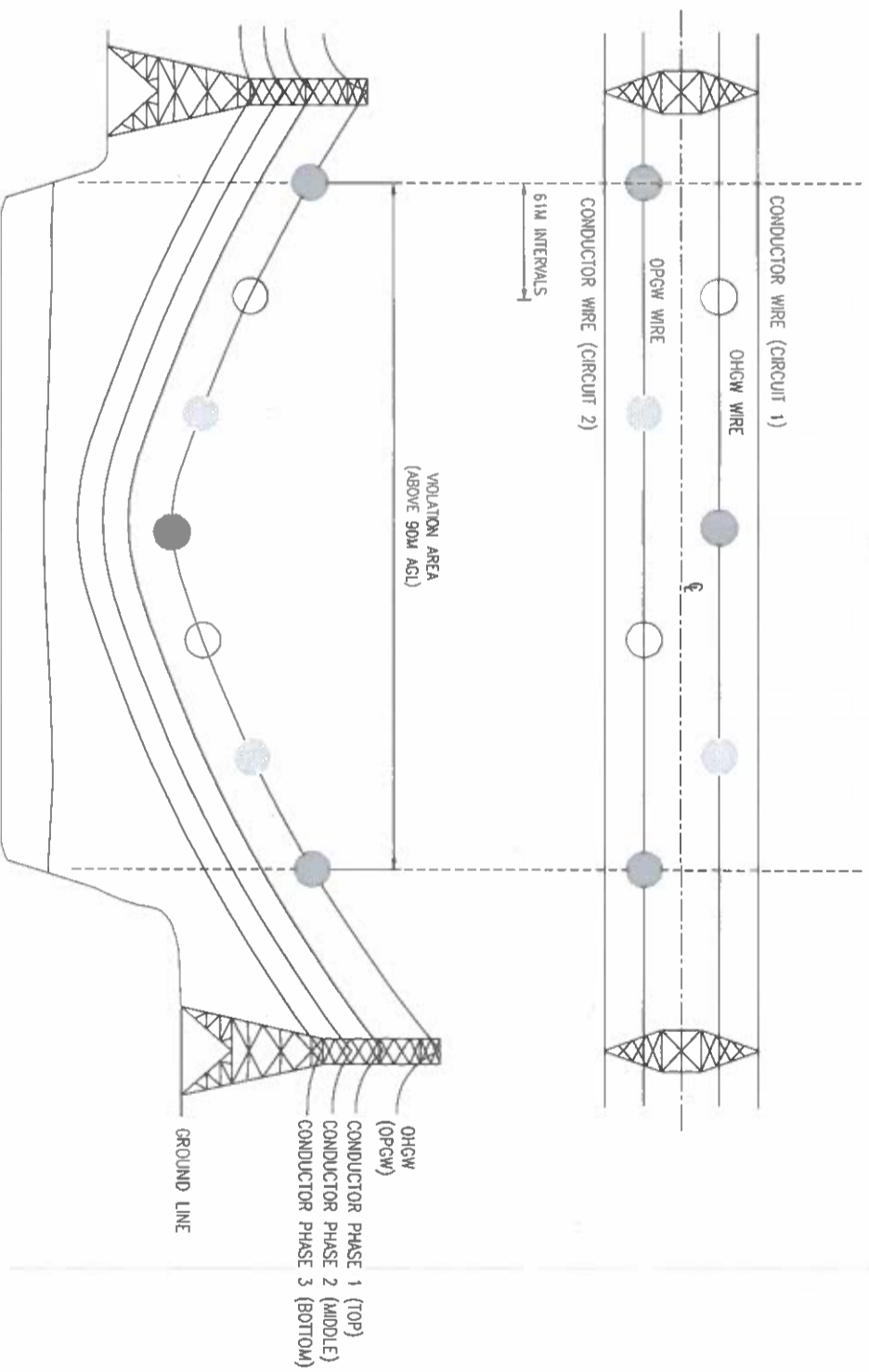


ITEM NO.	PART NAME	DESCRIPTION	REQUIRED QUANTITY
1	BALL HALF		2
2	LASHING RODS		2
3	CAP SCREW		4

CATENARY UNLIGHTED MARKERS

REQUIRED FOR TRANSMISSION LINES OVER 69KV
RECOGNIZABLE FROM A MINIMUM DISTANCE OF 1.200M

WIRE MARKER BALLS MAY BE STAGGERED OVER THE CATENARY TO
ENABLE BETTER WIND LOAD DISTRIBUTION



- NOTES:
1. EXTENSIVE CATENARY WIRES: MIN. 36 INCH (91 -CM) DIAMETER MARKER BALLS; LESS EXTENSIVE CATENARY WIRES: 20 INCH (51 CM) OR 12 INCH (30.48 CM) DIAMETER MARKER BALLS. FOR 400KV NEPAL PROJECT, RECOMMENDED TO USE 91 CM MARKER BALLS (WEIGHT =9kg).
 2. MARKER BALLS WILL BE EVENLY SPACED ALONG THE WIRE AT APPROXIMATELY 61M INTERVALS.
 3. UNLIGHTED MARKER BALLS SHOULD BE SOLID COLOR, SUCH AS AVIATION ORANGE, WHITE OR YELLOW.
 4. UNLIGHTED MARKER BALLS SHOULD ALTERNATE AVIATION ORANGE, WHITE YELLOW WITH AVIATION ORANGE MARKERS POSITIONED AT EACH END.
 5. IF LESS THAN FOUR UNLIGHTED MARKER BALLS ARE ON THE LINE, ALL MARKER BALLS SHOULD BE AVIATION ORANGE.

PRELIMINARY DESIGN. EPC CONTRACTOR TO PROVIDE THE FINAL DESIGN FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY POWER ENGINEERS FOR THE PROJECT. THE CLIENT HAS REVIEWED AND APPROVED THE DRAWING FOR THE PROJECT. THE CLIENT HAS REVIEWED AND APPROVED THE DRAWING FOR THE PROJECT. THE CLIENT HAS REVIEWED AND APPROVED THE DRAWING FOR THE PROJECT.

REV	ISSUED FOR BID	REVISIONS	DATE	DRN	OSGN	CHKD	APRD
0			8-14-19	DWV	CM	CM	

REV	ISSUED FOR BID	REVISIONS	DATE	DRN	OSGN	CHKD	APRD
0			8-14-19	DWV	CM	CM	

OSGN	CHKD	APRD	SCALE	FOR 1:100 DWG ONLY
OSGN	CHKD	APRD	N.T.S.	

Subconsultant:
POWER ENGINEERS

MILLENNIUM CHALLENGE ACCOUNT (MCA) - NEPAL
400KV TRANSMISSION LINE
DOUBLE CIRCUIT LINE
CATENARY UNLIGHTED MARKERS
MARKER BALL SPACING

Client:
MILLENNIUM CHALLENGE CORPORATION
UNITED STATES OF AMERICA

Consultant:
Stantec



Funded by:
MILLENNIUM CHALLENGE CORPORATION
UNITED STATES OF AMERICA



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Job Number
153312

Drawing Number
MB-SHT-1



E - 6

Nepal Aviation Mark Ball Locations kmz – provided electronically



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