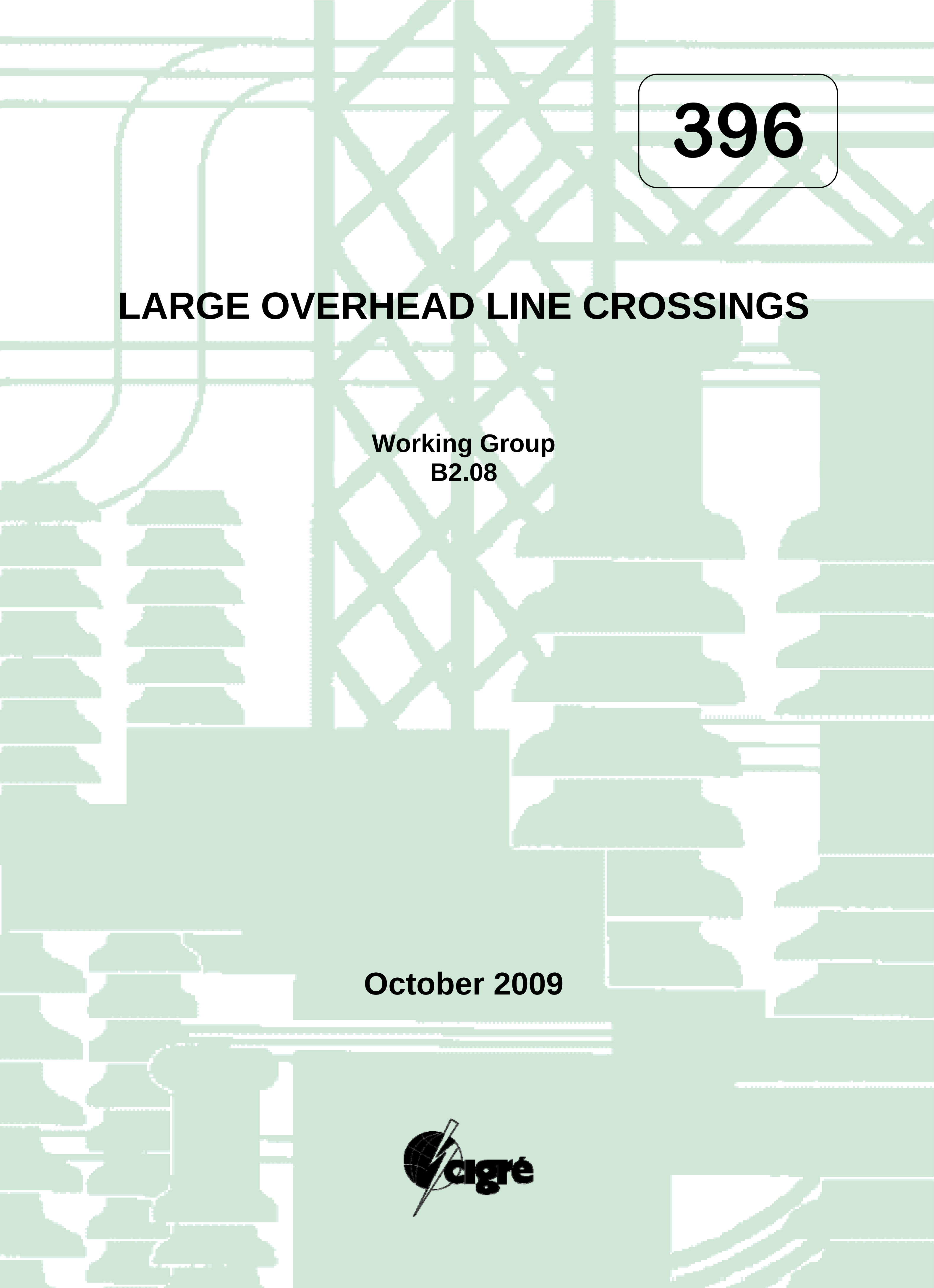

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LARGE OVERHEAD LINE CROSSINGS

Working Group
B2.08

October 2009

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LARGE OVERHEAD LINE CROSSINGS

Jamuna River crossing - Bangladesh

Ameralik Fjord – Greenland

New Elbe River – Germany

Marakaibo Lake – Venezuela

Yangtze River crossing – China

Uruguay River – Brazil

CIGRÉ SC B2
Working Group
WG-08

Revision February 2009

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ABSTRACT

Finding new routes for high voltage overhead lines may require designs that address obstacles such as valleys, wide rivers and arms of seas. Large overhead line crossings are designs at the limit of the “state-of-the-art,” as they demand long spans and/or tall supports. Standards do not cover all necessary load assumptions and design approaches. Information about crossing projects already constructed could assist policy makers and designers to make decisions. With the help of a questionnaire worldwide circulated by Cigré SCB2.08, a database was developed. It shows records of spans, tower heights and their trends. In addition, it provides indications of conductor types, their tension with vibration control devices, sags, insulator strings, tower weights and foundation reaction forces. The collected data can be used to determine rules and recommendations for the design of large overhead line crossings regarding choice of conductors, phase spacing and wind load assumptions.

1. INTRODUCTION

World-wide electrical power grids are growing. Local networks are interconnected, power is exchanged between regions, countries and continents, and electric current is transmitted from power generation plants to the consumers bridging long distances and often passing rough terrain. Projected increases in demand for power as well as environmental constraints necessitate overhead lines being routed into regions where long-span “crossings” could provide economies over traditional transmission lines, particularly if these lead to a reduction in the line total length. Crossings of valleys, wide rivers, and arm of seas require extra high supports and long spans which have been successfully installed in many countries.

Crossings are currently designs at the limit of the "state-of-the-art”. Crossings are unique projects and standards often do not cover the wide range of load assumptions and design approaches which are necessary for crossings. To determine rules and recommendations for the design of large overhead line crossings, it would be helpful if the designers and policy makers could have available information about other crossing projects already constructed and in operation in the world. Such data and reports for crossings could be utilized to benchmark different design practices applied in different countries in the past.

For that purpose, the task force Cigré SCB2.08 TF6 was created to built-up a database of crossings world-wide. The group developed and distributed a questionnaire (see Annex) in order to collect the technically relevant data of crossings. As large overhead line crossings are complex and unique projects, it was realized from the beginning that it would be probably very difficult to collect homogeneous and complete information about those constructions. For this reason, the questionnaire was split in two parts. Part A was composed of basic information only, having few questions and being very easy to answer. Part B was the complete questionnaire comprising all the relevant data that could be available. To be included in the database, at least part A of the questionnaire should be completely answered. A research of available literature was started in parallel for getting additional information. An evaluation of the available data is given here in this report. A first attempt regarding rules and recommendations for the design of large overhead line crossings is presented.

2. Definition of Large Crossings and Design Parameters

For the purpose of this study, overhead lines with spans ≥ 1000m and/ or tower heights ≥ 100m were defined as large crossings (figure 1), but there was no restriction regarding the voltage level. The questionnaire asked for the basic design data like location, nominal voltage, number of circuits, phase conductors and earthwires, clearances, sags, spans, tower heights and weights, and for further details like power transmission capacity, load assumptions, phase configuration, phase spacing, conductor data (every day stress, maximum working load, vibration control system, clamping method), insulator string data, crossing tower type, main member forces and reaction loads as well as foundation design data.

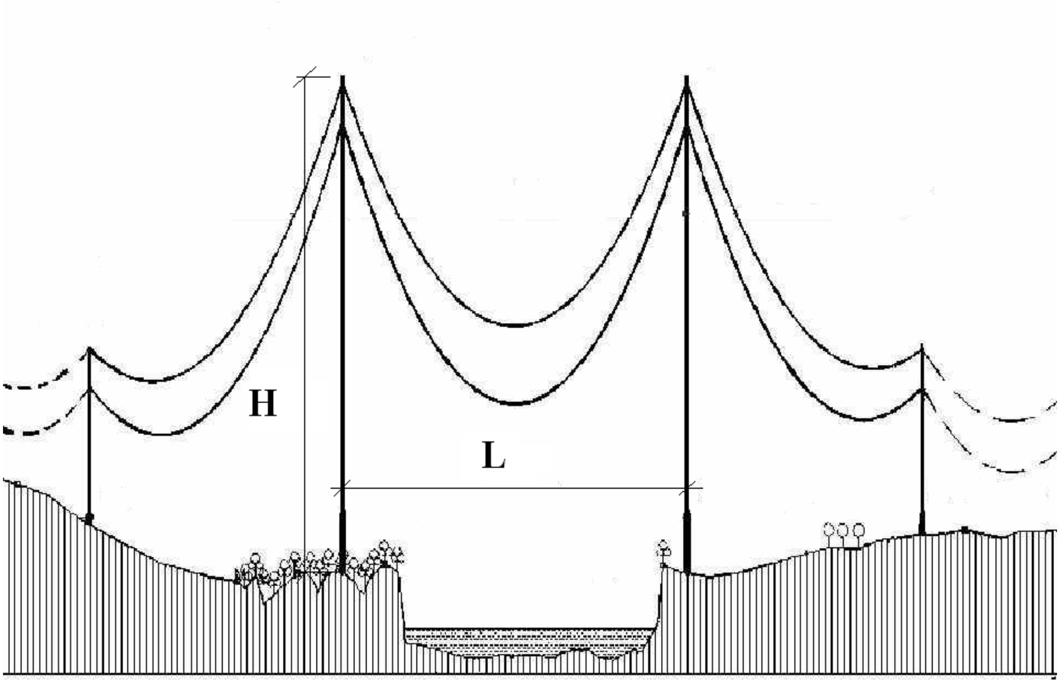

Figure 1 – WG08TF6 Large Crossing definition

3. Data Collection

After 5 years of data collection, the situation regarding the responses to the questionnaire was not so satisfactory. Nevertheless, 23 responses to part B, the complete questionnaire (see ANNEX), were received from 17 countries by the Cigré SCB2.08 TF6. Detailed data were collected from crossings in Belgium, Brazil, China, Czech Republic, Egypt, Germany, Greenland, Iran, Italy, Mexico, Norway, Panama, Portugal, Slovakia, Turkey, USA and Venezuela. The question arose whether those responses - still partly incomplete - are adequate for a database as initially imagined to be the Cigré Technical Brochure on “Large Overhead Line Crossings.”

Therefore, over 60 references have been examined during the study of the literature, and another 30 publications were found. According to the definition herein adopted, 243 crossings were identified in 38 different countries. Each crossing was entered into the database to permit analysis. Naturally, the database remains incomplete as the desirable information was not never fully provided in the sources. In most of the cases, only part A of the questionnaire was responded providing just basic information such as name of the crossing, sometimes span and tower height or conductor type, number of circuits, etc.

Nevertheless, interesting informations were accumulated by the Cigré SCB2.08 TF6. The following discussions show data obtained from the most interesting crossings. It is expected, however, that the identification of the crossings can provide an incentive to the experts world-wide to contribute with additional information in order to enlarge the database in the future.

4. Data Analysis; statistics

4.1. Types of crossings

As seen in table 1, five crossing types were identified during the evaluation of the received data:

Table 1: Crossing configuration types

Type	Description	Formula	Application
A	Enhanced design crossing	-	with normal or extended towers, anchor towers without line angle but sufficient phase span
B	Anchor tower – Anchor tower	[A - A]	two anchor towers only, to be applied for large valley or fjord crossings providing naturally high embankments for sag clearance
C	Anchor tower – A number n of suspension towers – Anchor tower	[A - n x S - A]	normal crossing type for rivers and arms of seas [A - 2 x S - A], in case of long spans and acceptable intermediate foundation conditions with two or more suspension towers
D	Same as C above but with a constant tension	[X - S - A]	Italy, Messina Strait Crossing (*)
E	n x Suspension tower but earthwire directly ground anchored	[X - n x R - X]	USA, Tacoma Strait Crossing (*)

A – Anchor Tower
S – Suspension Tower
X – Constant conductor tension by pulleys and weights
R – Ground anchored towers instead of anchor towers
(*) – The crossing configuration has been dismantled

The most applied crossing types around the world so far are from the types B and C (figure 1 for C type).

4.2. Longest crossings

Table 2 ranks the 10 longest crossing projects in the database. The definition of “crossing” is here taken from anchorage to anchorage towers (A-A). The longest crossing in the world is still the Jamuna River Crossing in Bangladesh constructed in 1983, with 13.6 km (figure 2) followed by the Maracaibo Lake Crossing in Venezuela (Figure 3).

Table 2: Longest crossings

No.	Name of crossing	Country	Voltage [kV]	Crossed obstacle	Crossing type	Max tower height [m]	Max single span [m]	Total crossing length [m]	N° Circuits	Year of comple tion
1	Jamuna	Bangladesh	230	River	A-10xS-A	111	1220	13640	2	1983
2	Maracaibo Lake (Curata)	Venezuela	400	Lake	A-7xS-A	148.2	1500	8750	1	1996
3	Orinoco	Venezuela	115	River	A-3xS-A	246	2537	5836	2	1994
4	Ameralik Fjord	Greenland	132	Fjord	A-A	18	5374	5374	1	1993
5	Sognefjord (Ramnaberg-Fatlaberget)	Norway	66	Fjord	A-A	N.A.	5012	5012	1	1955
6	Messina Straits	Italy	220	Sea	X-2xS-X	224	3646	4928	2	1955
7	St. Lawrence (Boucherville-Duvernay)	Canada	735	River	A-3xS-A	154	1394	4920	1	1968
8	Sognefjord II	Norway	300	Fjord	A-A	N.A.	4735	4735	1	1975
9	Sognefjord (Refsdal-Fardal)	Norway	132	Fjord	A-A	68	4600	4600	1	1985
10	Sognefjond I	Norway	300	Fjord	A-A	N.A.	4552	4552	1	1964

Figure 2: 230 kV Jamuna River crossing, Bangladesh

Figure 3: 400kV Maracaibo Lake crossing, Venezuela

4.3. Longest single spans

Table 3 reports the longest single crossings spans in the database. The Ameralik Fjord crossing in Greenland constructed in 1993 is the longest single crossing span in the world (figure 4). Following Greenland, Norway, China, Japan and Canada have the longest single spans. The conductors of the Messina Straits Crossing have been dismantled in the meantime.

Table 3: Longest single spans

No.	Country	Name of crossing	Voltage [kV]	Crossed obstacle	Crossing type	Max tower height [m]	Max single span [m]	Total crossing length [m]	N° Circuits	Year of comple tion
1	Greenland	Ameralik Fjord	132	Fjord	A-A	18	5374	5374	1	1993
2	Norway	Sognefjord (Ramnaberg-Fatlaberget)	66	Fjord	A-A	N.A.	5012	5012	1	1955
3	Norway	Sognefjord II	300	Fjord	A-A	N.A.	4735	4735	1	1975
4	Norway	Sognefjord (Refsdal-Fardal)	132	Fjord	A-A	68	4600	4600	1	1985
5	Norway	Sognefjord I	300	Fjord	A-A	N.A.	4552	4552	1	1967
6	Norway	Langfjorden	132	Fjord	A-A	N.A.	3973	3973	1	1968
7	Norway	Sunndalsfjorden	132	Fjord	A-A	N.A.	3800	3800	N.A.	1971
8	Norway	Sunndalsfjorden I	300	Fjord	A-A	N.A.	3785	3785	1	1972
9	Norway	Sunndalsfjorden II	300	Fjord	A-A	N.A.	3785	3785	1	1972
10	Italy	Messina Straits	220	Sea	X-S-S-X	224	3646	4928	2	1955

Figure 4: 132 kV Ameralik Fjord Crossing, Greenland

4.4. Tallest crossing towers

The tallest 10 crossing towers in the world are shown in table 4. According to the actual information of the database, the most exceptional crossings with tall supports have been erected in China followed by Venezuela, Germany, Japan and Egypt.

It is important to note that the Jiangyin Yangtze River Crossing tower with a height of 346.5m (figure 5) represents a remarkable record exceeding by about 90 meters the second highest tower crossing of the world, still in China, with 257 meters.

Table 4: Tallest towers

No.	Project Name	Country	Voltage [kV]	Span [m]	N° Circuits	Conductors per bundle	Max tower height [m]	Tower type	Year of completion
1	Jiangyin Yangtze River Crossing	China	500	2303	2	4	346.5	Lattice box angle steel	2004
2	Nanjing Yangtze River Crossing	China	500	2053	2	4	257.0	Reinforced concrete	1992
3	Orinoco River Crossing	Venezuela	230	2537+ 2161	2	1	240.0	Lattice box angle steel	1992
4	Zhujiang Crossing	China	500	1547+ 931	2	2	235.8	Lattice box angle steel	1990
5	Wuhu Yangtze River Crossing	China	±500	1910	2	4	229.0	Tubular tower	2003
6	Elbe River Crossing	Germany	380	1200	4	4	227.0	Lattice box angle steel	1978
7	Chusi Crossing	Japan	220	2357	2	1	226.0	Tubular tower	1962
8	Daqi Channel Crossing	Japan	220	2145	2	1	223.0	Tubular tower	1997
9	Suez Canal Crossing	Egypt	500	600	2	4	221.0	Lattice box angle steel	1998
10	LingBei Channel Crossing	Japan	500	1463	2	4	214.5	Tubular tower	1993

**Figure 5: 500kV Jiangyin Yangtze River Crossing.
In the foreground the anchor towers, one for each circuit.
In the background one 346.5m tall suspension tower.**

4.5. Voltage levels and number of circuits

One circuit per crossing is the most used solution found in the database. In some cases, for instance in Canada, single circuit crossings in parallel were also adopted. In many circumstances, however, double circuit line crossings were constructed. At least in two cases, the Elbe River Crossing in Germany and the 3rd Bosporus Crossing in Turkey, four circuit crossings were installed.

As far as voltage levels are concerned, the analysis shows crossings from 66 to 735kV. It is interesting to note that important crossings with the voltage levels of 400kV and 500kV prevail. This can be understood as a consequence of the relation between the high crossing costs and their power transfer capabilities. Only in Canada, there are 735kV crossing lines.

4.6. Evolution on long spans per year

Figure 6 shows the evolution of longest single span crossings per year of construction. The analysis of the graph reveals an increasing trend of span lengths. Crossing spans are getting longer with the time.

4.7. Tallest supports per year

The analysis of the support heights per year of erection shows a rising up trend. Structure heights, on average, are getting taller (figure 7), and more crossings are being constructed as time passes.

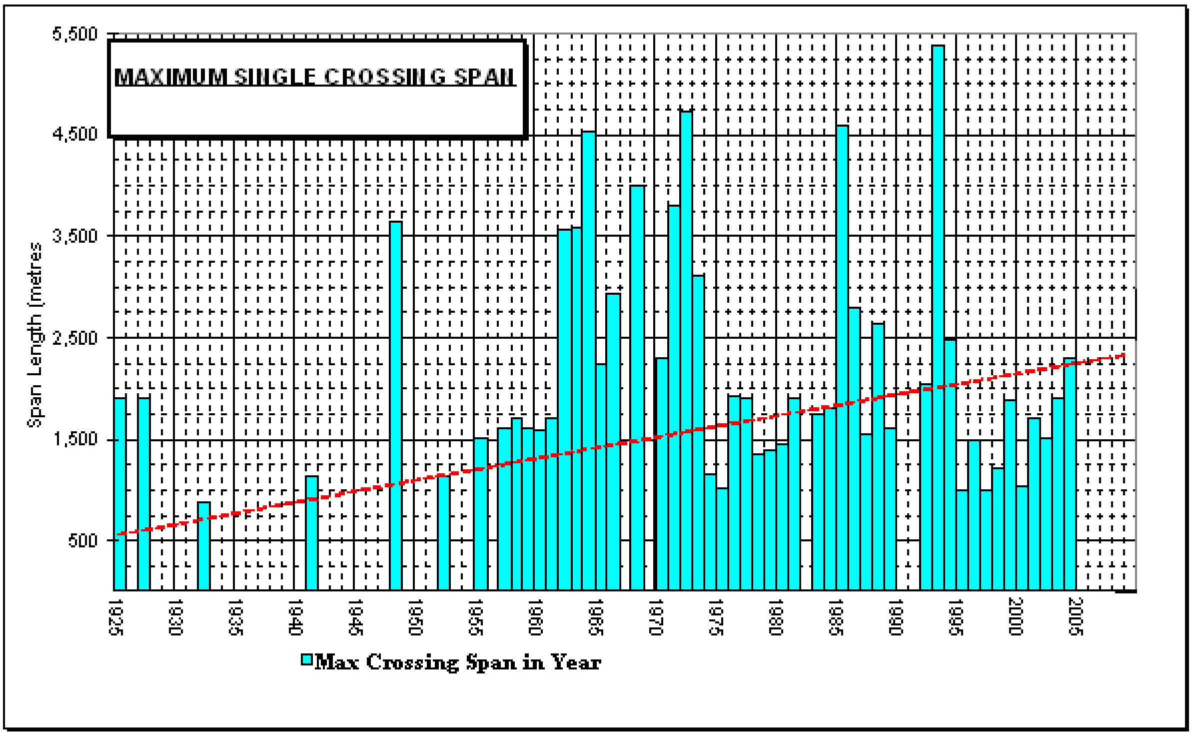

Figure 6: Longest Spans of Crossing Supports by Year

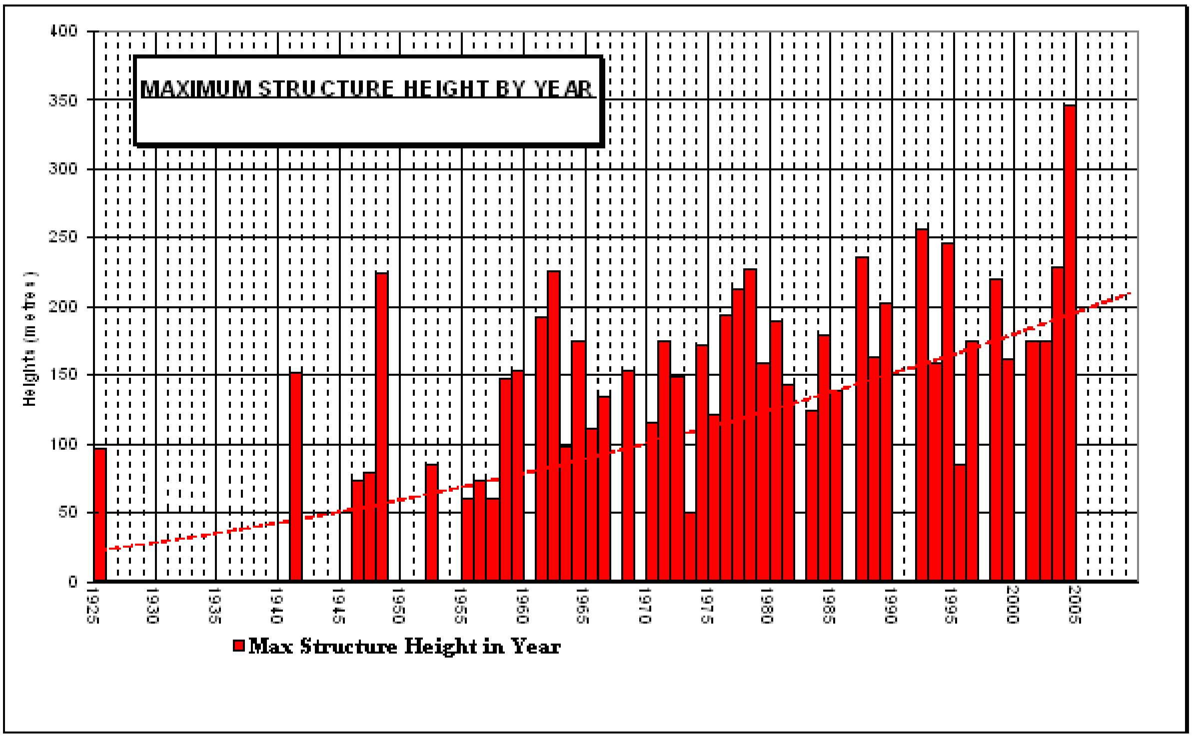

Figure 7: Maximum Height of Crossing Supports by Year

5. Future trends; recommendations

The statistics provide the evidence that overhead line crossings trend is longer spans, taller supports and more projects per year. This trend shall be seen as a justification and a necessity for providing general design rules and recommendations derived from the projects implemented in the past. Technical conclusions are desirable regarding:

- Conductor choice and conductor tension
- Phase spacing
- Wind load determination
- Tower weight estimation
- Costs of crossing.

5.1. Conductor Choice

From the experience of the existing crossings, the criteria for the choice of conductor types for the new crossings should be:

- Aluminum alloy (A2 or A3 as per IEC 61081) should preferably be used instead of Aluminum (A1) due to the higher strength capacity,
- Steel conductors and steel wires in conductors with Aluminum play an important role for the limitation of the sag,
- Regarding the thermal current capacity, the optimum is 1A/mm2 of Aluminum (or Aluminum alloy) in order to avoid too many losses,
- In order to combine both high current capacity and minimized sag, the optimum ratio between the Aluminum alloy (A2 or A3) and the Steel core should be in the range of 8:1,
- Smooth surface of the chosen conductor with formed wires decreases the aerodynamic factor and makes stringing of a bundle easier.

Due to their high strength, steel conductors guarantee the lowest sag compared with all other types of conductors. Aluminum alloy (AACSR) conductors with high strength steel reinforced provide also a good tension/weight - ratio for achieving reasonable sags. The majority of the crossings in the database use ACSR or AACSR conductors with the Aluminum/ Steel - ratio between 1:1 and 3:1, but economic and technical investigations are recommended as they could result in a higher part of Aluminum (e.g. 8:1 for the Bosphorus crossing).

Regarding the conductor configuration, advantages and disadvantages of single and bundle conductors should be considered (Table 5).

The every day stress (EDS) of the conductors differs between 13% and 36% (the latter value for steel conductors with damping devices) of the ultimate tension strength according to the data available from the database. The decision regarding the EDS has always to do with susceptibility to vibration, damping measures and sag limitation. An optimum value seems to be between 20% and 22% for past projects.

Table 5: Conductor Configuration

Conductor Configuration	Advantage	Disadvantage
Single	• Smaller edge field strength • Higher ice load capacity	• Higher AC – resistance, Al – section not fully used for current transmission • Manufacture due to high diameter • Stringing equipment due to high diameter • Special fittings due to high diameter • Higher loads on tower and foundation
Bundle	• Al – section is fully used for current transmission • better conductor damping due to smaller diameter	• galloping • torsional stability • unbalanced icing • damaging of spacers

The actual requirements of minimizing the environmental impacts of overhead transmission lines (reduction of height and visibility) resulted in increasing conductor tension and improvement of vibration damping. New research in lighter and stronger conductors e.g. ACCR (3M Composite Conductor) or ACCC (Carbon Fiber Core) will help achieving these targets. The Composite or the Carbon Fiber Core conductors are non-homogeneous conductors consisting of high-temperature aluminum-zirconium (Al-Zr) or other alloys strands covering a stranded core of fiber-reinforced composite wires. Both the composite core and the outer Al-Zr strands contribute to the overall conductor strength. Due to their economic advantages, the increased usage of ACCR or ACCC type conductors is only a matter of time, particular for existing crossings where increased current capacity may be required.

5.2. Phase Spacing

Some international standards like EN 50341-3-4 (Germany), HB C(b)1: 1999 (Australia), NESC (USA) give formulas for phase spacing calculations. All formulas are a function of the conductor's sag and voltage levels. A comparison between required spacing as per standards and actual values used for crossings has shown an over-design approach for the crossings. Reasons for increased phase spacing could be that crossings were placed into a higher reliability class than normal overhead transmission lines and galloping was considered in regions where ice loads could occur.

Taking the information regarding conductor spacing from the database, a comparison with a conservative German (spacing formula 1 = $0{,}7\times\sqrt{sag}+\frac{U_m}{150}$) and a Norwegian formula (spacing formula 2 = $0{,}1\times sag$) shows the safety margins which have been possibly considered for uncertainties. A modified Norwegian formula could well reflect the actually used horizontal conductor spacing (figure 8).

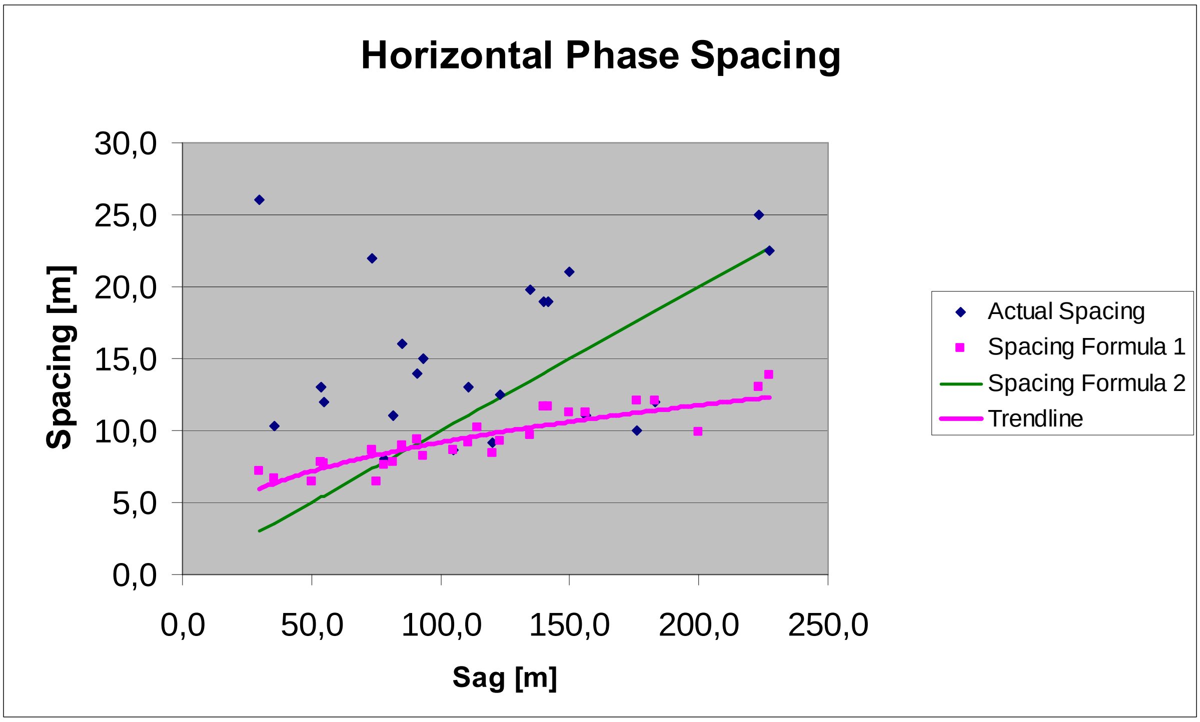

Figure 8: Phase Spacing Relation

5.3. Wind Loads

The wind loads affect decisively the design of all overhead line crossing components. Wind loads generally control the design of crossings because of the exceptional dimensions of the conductor spans and tower heights involved. Very high wind loads can become crucial for the conductor's mechanical strength. It could result in uneconomic every day stresses when calculating the sag and tension tables. The mechanical design of the insulators and fittings depends directly on the maximum conductor tensions, and the weights of the tall supports are affected predominantly by the wind load on the tower structure itself.

Looking at the design wind loads for some crossing projects and their geographical locations, the values seem to be conservative and too much on the "safe side", resulting in over-design of all crossing components. The reason for such conservative load assumptions is the common approach to extrapolate the wind loads, used for normal overhead transmission lines, to exceptional dimensions of the spans and heights of the crossings. But the standards for wind load assumptions like IEC 60826, EN50341-1, EUROCODE 1 or even ASCE Manual No. 74, mostly restrict the application of their formulas for wind velocity calculations up to an altitude of maximum 100m above ground. High altitude wind streams prevail in heights of 200m to 500m which have different characteristics compared with wind in lower altitudes. Their values do not increase in such extent when applying the formulas of the standards with a ground wind speed basis. Therefore, wind studies should be performed for large crossings with tall towers and high conductor positions. Additionally, the effect of a gust acting on a conductor in a long span is significantly smaller than for normal spans, as gust widths are limited.

It is not possible to give universally applicable recommendations for the design wind loads as the local conditions, particular meteorological models and wind measure records have to be considered for the determination of the design wind speed. It is recommended to consult meteorological experts in this regard. Special parameters concerning design wind loads are as following:

- reliability levels (wind return period >500 years)
- high altitude wind streams
- gust width factor
- natural frequency and dynamic effect of wind to tall structures
- partial streaming of wind in different height zones.

5.4. Weight Estimation

The estimation of the crossing tower weight is one of the most desirable information at an early stage of the planning, particularly when tall supports are required. A tower weight estimation is nearly impossible without having loads and reaction forces. The following table shall provide some examples for tower weights of existing tall towers:

Table 6: Examples for Tower Weights

Project	Circuits	Height [m]	Weight [t]
Yangtze River	2 x 500kV	346	4192
Pearl River	2 x 500kV	235	1040
Elbe River	4 x 380kV	227	980
Suez Canal	2 x 500kV	220	750
Orinoco River	2 x 230kV	240	650
Yangtze River	2 x 500kV	180	540
Bosporus	4 x 420kV	161	490

5.5. Economics

The future use of overhead line crossings will be subject to economics and assessment of environmental impacts over its competitors, above all, insulated cables. In May 1996 CIGRÉ Joint Former Working Groups 21/22 presented their report for normal terrain overhead transmission lines compared with cables. The "Overhead" option cost was reported to be about 15%, 8% and 5% of the cable solution cost, for 132kV, 230kV and 400kV respectively. Those ratios, however, cannot be used for crossings. A cost estimation for a special crossing project (500kV) shows an advantage for the OHL which costs around 25% of the cost of a cable crossing solution.

Nowadays, overhead transmission lines including large crossings are still the utilities' typical first choice due to advantages regarding power transfer capability, maintainability and economics, provided that their environmental impact are minimized.

Typical cost make-up of crossings can be estimated as shown in Figure 9.

Figure 9: 500kV Uruguay River Crossing: Crossing with elevated foundations

Figure 10: 380 kV "Deurganckdock Crossing": Doel, Antwerp, Belgium

6. CONCLUSIONS

Crossing records indicate that "obstacles" become less so with time. Yesterday's obstacles are today's challenge. Crossing designs in the past have generally been conservative. Economies may be realized for new designs by studying performance records of previous "long-span" and "high-tower" crossings. Derived rules and recommendations shall give necessary support.

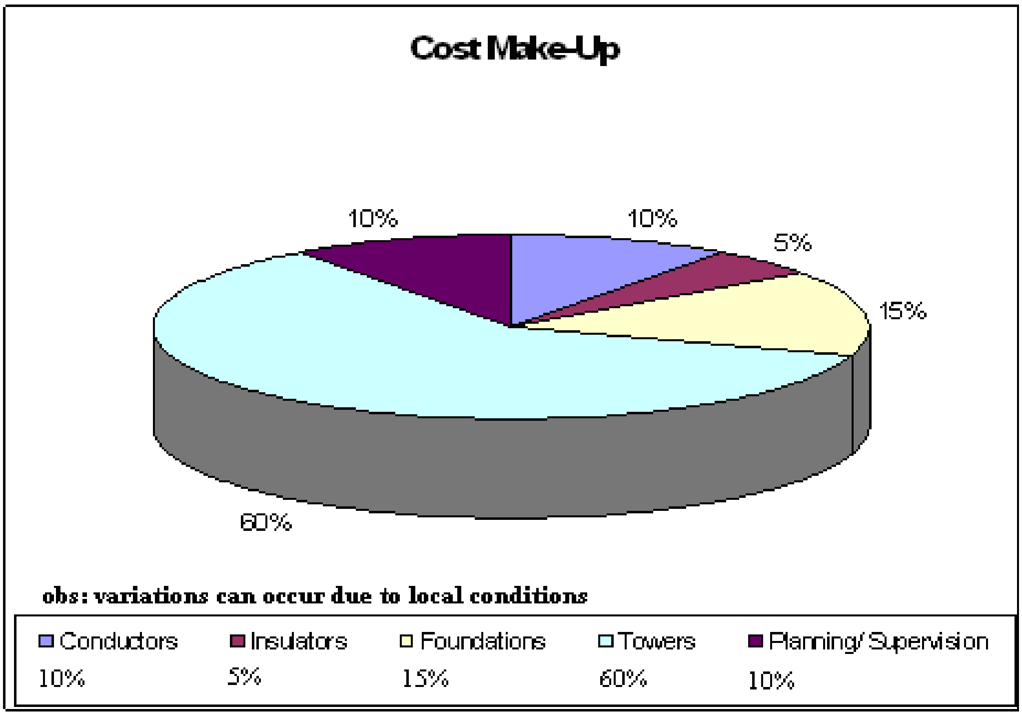

Figure 11: Typical Cost Make-Up for Crossing Type C (A-S-S-A with tall suspension towers)

Developments of high-strength, high capacity conductors will be driven by "market-demand." Such conductors will, in turn, lead to longer crossings with shorter towers and less environmental impacts for future designs.

7. ACKNOWLEDGMENTS

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ANNEX

SC B2.08 TF6 - QUESTIONNAIRE
“LARGE OVERHEAD LINE CROSSINGS”

CIGRÉ FCB2.WG08

TF6 – LARGE OVERHEAD LINE CROSSINGS

- QUESTIONNAIRE -

Source	(**please enter here** who you are and complete a worksheet for each crossing which meet the following conditions)
Definitions	**Large crossing : span >= 1,000m OR tower height >=100m.** **The objective is to identify the engineering principles adopted to overcome the "crossing" obstacle**
(Note)	NOTE : the following definitions SHALL also APPLY N/A = Information is NOT AVAILABLE (assumed default for items left blank) N/R = Item is NOT RELEVANT or NOT APPLICABLE (give reasons) Crossing Section : from anchor support to anchor support Crossing span : main crossing span
Other definitions employed by respondee	…………………………………………………………………………………………………… …………………………………………………………………………………………………… …………………………………………………………………………………………………
Request	This data sheet is split into two parts: **Part A : Basic Data** - the minimum data considered necessary to describe the crossing to be of use to the TF - **PLEASE COMPLETE FOR EACH CROSSING** **Part B : Detailed Data for the Crossing (optional, please provide if available)** Please complete (where available, and quote the source) the following items for EACH crossing in your country - or sphere of influence for which you have data. It is suggested this worksheet is copied into another worksheet for each crossing. A summary of data collected will be issued for checking / correction / addition. **If you know others who have information regarding Large Crossings please forward this questionnaire to them**

PART A : BASIC DATA	**Minimum (required) data** (enter your data in this column only)
Crossing name / ID	
General description (i.e. twin suspension crossing with anchor towers - crossing over river)	
Date of construction or commissioning	
Country of construction	
Crossing location (crossing what?)	
Nominal voltage (kV)	
No. of phases	
Arrangement of phases (horizontal, delta, vertical, other)	
Phase conductor type, number per phase and size	
Earthwire type(s) and size	
Crossing clearance to obstacle (m)	
Crossing Section spans (m)	
Max. sag in longest span (m)	
Tower height(s), weight(s)	
Form of construction	
other available & interesting information	
References (please provide copies)	
Photo	
PART B : DETAIL DATA	(Optional, if available)
General	
Phase-to-phase distance (m)	
Phase-to-earthwire distance (m)	
Earthwire Shielding angle (deg)	
Duration of design	
Transfer capacity (MW)	

Conductor	
Type	
No. per phase	
Bundle internal distance (cm)	
Max. temperature	
Current capacity (A)	
at temp (deg C)	
and wind velocity (m/s)	
Ultimate Tensile Strength (kN)	
Working load (tension) (kN)	
EDS (%) at deg C	
EDS Parameter (m)	
Antivibration system	
Clamping method (tension/suspension - length of clamping)	
other available & interesting information	
Earthwire	(note OPGW below)
Type	
No. provided	
UTS (kN)	
Working load (kN)	
EDS (%)	
EDS Parameter (m)	
Anti-vibration system	
Clamping method (tension/suspension - length of clamping)	
other available & interesting information	
OPGW	
Type	
No provided	
Clamping method (tension/suspension - length of clamping)	
UTS (kN)	
Working load (kN)	
EDS (%)	
EDS Parameter (m)	
Antivibration system	
other available & interesting information	
Suspension String	
Overall Length of set (m)	
No. of insulator strings per set	
Insulators type	
Insulators material	
No. of insulator units per string	
Insulators UTS (kN)	
UTS of overall set (kN)	
Working load of overall set (kN)	
Suspension clamp type	
No. of connections to tower	
other available & interesting information	
Tension Insulator String	
Overall Length of set (m)	
No. of insulator strings per set	
Insulators type	
Insulators material	
No. of insulator units per string	
Insulators UTS (kN)	
UTS of set (kN)	
Working load of set (kN)	
Tension clamp type	
No. of connections to tower	
other available & interesting information	

Crossing Tower	
Type (suspension / tension)	
Height above GL (m)	
Base size a x b (m)	
Main member type and size	
Main Diagonal type and size	
Mass per tower (kg)	
other available & interesting information (number of bolts, etc...)	
Suspension tower foundations	
Type (pad&chimney / bored pile / driven pile / other	
Depth (m)	
Height above ground (m)	
Method of tower anchoring	
other available & interesting information (concrete vol, reinforcing weight, etc)	
Reaction Tower for crossing	
Type	
No. per crossing	
Height (m)	
Base size a x b (m)	
other available & interesting information	
Reaction tower Foundations	
Type	
Depth (m)	
Height above ground (m)	
Method of tower anchoring	
other available & interesting information (concrete vol, reinforcing weight, etc)	
Miscellaneous	
Anticlimbing system type	
Scales	
Elevator / Lift provided	
Aircraft warning system type (by day and night)	
other available & interesting information on misc items (power supply, etc)	
Loading conditions for suspension towers	(identify conditions for tower, insulators, earthwire, OPGW and conductors if different)
Basis of loading - FOS, ultimate, etc	
maximum wind velocity or pressure (identify if varies by height)	
wind velocity (m/s) or pressure (kN/m2) simultaneous with ice thickness (mm) (identify if varies by height)	
Ice only condition (mm radial thickness)	
mass of ice (% of tower mass)	
other available & interesting information on loading	
Other Special loading conditions	
Other Special design conditions	
Other (interesting) data	
Drawings /Photos	(identify if any are available and submitted with your response)