Corus Construction & Industrial

Jumbo sections

Helping you to shape the world

Faster, higher, stronger

The Olympic motto captures perfectly the advantages of construction using jumbo sections.

Corus has substantial experience in the manufacture and application of jumbo sections.

Some major developments that we've been involved in include:

- 7 World Trade Center, New York, USA
- 383 Madison Avenue, New York, USA
- Jin Mao Building, Shanghai, China
- Petronas Towers, Kuala Lumpur, Malaysia
- Guangdong Olympic Stadium, Guangzhou, China
- Barclays Bank Headquarters, Canary Wharf, London

Benefit from manufacturing excellence through advanced technology

Jumbo sections are cast from ultra clean steels and precision rolled in our powerful and technically advanced beam mill.

Manufacturing consistency and dimensional accuracy are assured by sophisticated process control equipment at every stage of production, together with the use of automatic gauge control in the mill.

We work closely with our customers

Over many years, close links have been forged with some of the world's most prestigious construction and steel fabrication companies. We're always pleased to offer technical and logistical support from the initial enquiry right up to finished construction.

Steel for a brighter future

Environmental protection is a key objective and the principles of sustainable development run throughout our operations. Currently around 80% of by-products associated with the making and rolling of steel are recycled; steel itself is one of the most recyclable materials available.

Quality Assurance

Corus' manufacturing plants are assured to ISO 9001, undertaken by Lloyds Register of Quality Assurance. In addition we hold approvals from a range of national certifying authorities.

Faster

One Churchill Place, Canary Wharf, London

Architect: **HOK International**

Steelwork contractor: **Victor Buyck**

Steel supplier: **Corus**

Main contractor: **Canary Wharf Contractors**

Completion date: **2004**

Churchill Place, one of the five districts that make up Canary Wharf, consists of four landmark buildings. One Churchill Place, a 33-storey 510 feet (156m) high building, will house the world headquarters of Barclays Bank.

Jumbo sections support a tower of strength

Jumbo sections from Corus' beam mill form the vertical columns that give this building its robustness. Located at the end of the mill is the extra processing department, a specialist beam processor, which cut the columns to the exact length required for construction and milled the ends to give a very fine, mirror finish – so they were square and precisely parallel.

Speed – not downtime for steel fabricators

Steelwork contractor Victor Buyck used columns supplied by Corus' extra processing department in order to save time on the fabrication work. Prepared to the tolerance of depth of section/1000, the extra processing department delivered the columns directly to site, ready for use. They form the absolutely vertical, load-bearing frame.

Performance critical

The extra processing team can handle the full range of jumbo section sizes. Quality manufacturing performance is matched by delivery precision, working with customers to smooth the flow of materials through the supply chain. Corus can manage each stage of your logistics, ensuring that the right components are delivered on time and in full. The more that can be done at the mill where the sections are actually rolled, the less time our fabricator customers need spend transforming them into usable components.

The challenge of innovation – elevator construction

Most conventional elevators are installed after the building shell has been completed, which means that the engineers have to compete for access with other trades. The Schindler elevator system has a unique construction method – it is built at the same time as the building and is pieced together floor by floor as the structure goes up.

The Corus solution

In view of the huge size of the One Churchill Place contract, Schindler turned to Corus for help. Schindler provided the specifications and extra processing took charge – ensuring that every beam was cut, drilled, shot blasted, painted and delivered precisely in line with Schindler's requirements for constructing each shaft.

One Churchill Place, Canary Wharf, London
Corus' extra processing ensured rapid construction.

Higher

The Jin Mao Building, Shanghai

Architect: **Skidmore, Owings & Merrill**
Steelwork contractor: **Nippon Steel & Engineering Construction Co.**
Steel supplier: **Corus**
Developer: **China Shanghai Foreign Trade Centre Limited**
Completion date: **28th August 1998**

When Skidmore, Owings & Merrill designed the 88-storey, 1380 feet (420m) high Jin Mao Building for the China Shanghai Foreign Trade Centre Limited, they produced a spectacular skyscraper in traditional Chinese pagoda style.

The lucky number eight

The Jin Mao Building, which means 'much gold' in Chinese was completed on 28th August 1998. A lucky date for the Chinese, the building's eighty-eight storeys and dimensions – where each segment of the building is an eighth smaller than the sixteen storey base, all contain reference to the number eight. Corus supplied 10,000 tonnes of structural sections for this building, 2,000 tonnes of which were jumbo sections, mainly from its 800,000 tonnes per annum capacity beam mill.

Built to withstand typhoons and earthquakes

The building is designed to withstand all that Shanghai's tropical climate can throw at it, including violent and destructive typhoon winds of 125mph. In addition to climatic conditions, the Jin Mao tower was built to cope with earthquakes measuring up to 6 on the Richter scale. This is enabled by the lateral system linking the shear wall core and the mega-columns with the outrigger trusses and diaphragm slabs as if the building is sticking its arms out but has crutches in its hands for stability.

Multi-use project

The building comprises a mixture of shops, offices (from floors three to fifty) and the Grand Hyatt hotel from floors fifty-three to eighty-seven. The hotel has a central atrium, which is the full height of 38 storeys.

Precise project management

Co-ordination of the steelwork was key in the construction phase. The Nippon Steel & Engineering Construction Company, who built the imposing skyscraper, were able to rely on Corus' well developed international project management skills, ensuring an efficient and highly responsive customer focused supply chain.

This is an area of particular expertise, practised and perfected over many years, allowing our customers to concentrate on the main task of steel fabrication.

The Jin Mao Building, Shanghai
Raising the bar in skyscraper design.

Stronger

383 Madison Gardens, New York, USA

Architect: **Skidmore, Owings & Merrill**
Developer: **Sterling Equities & Hines for Bear Stearns & Co, Inc.**
Main contractor: **Turner Corporation**
Steel fabricator: **The Au Dragon Forge**
Steel supplier: **Corus**
Completion: **2002**

This 45-storey, 757 feet (230m) high office building is distinguished by a large octagonal glass beacon, which stands out like a lighthouse over Madison Avenue. Despite a relatively modest (by New York standards) number of storeys, the building accommodates the huge trading floors for brokers Bear Sterns and occupies the full block from Madison to Vanderbilt Avenues.

A fast track construction schedule in the heart of the East Side

To secure a completion time of sixteen months, the Turner Corporation – America's largest commercial building company – used approximately 7,860 tonnes of heavy built up components, including 1,455 tonnes of Corus jumbo sections in the construction of the Bear Stearns building.

Steel fabricator, the Au Dragon Forge of Canada, undertook the engineering, fabrication and erection of the frame, which involved some 10,810 drawings.

Innovative engineering solutions

The Bear Stearns building was constructed above the MTA/Metro North subway tracks, and required the use of sophisticated cross bracing to accommodate the building's cavernous trading floors and lobby.

The subway tracks only allowed a half size basement to be built, so the architects had to locate the building's core, elevators, stairwells and riser off-centre giving it an eccentricity which necessitated the additional strengthening from the cross bracing.

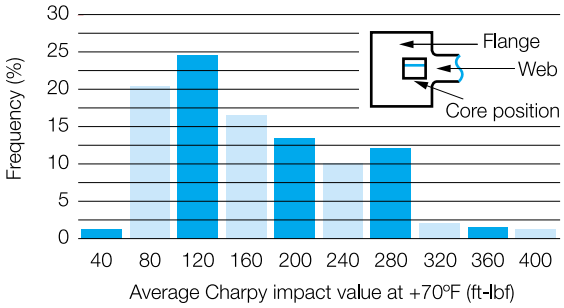
The building has an octagonal shaped 37-storey tower rising from a square 8-storey base. This shape with its eight exterior walls provides extra window space and more corner offices and also has the added advantage of blocking less light from the surrounding community. The final seven storeys light up to top the building with an impressive crown.

383 Madison Avenue, The Bear Stearns Building
Jumbo sections help support a financial heavyweight.

Photograph of the construction phase, 2000

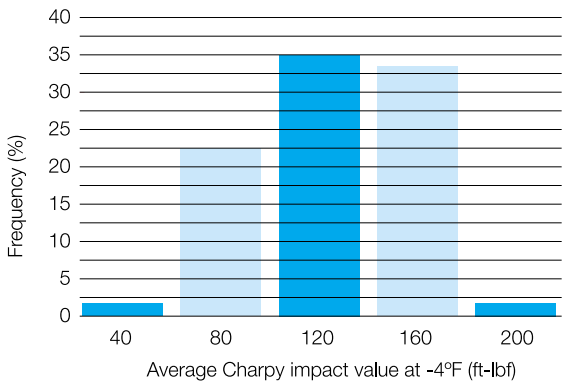
Jumbo section properties

Core average Charpy impact value



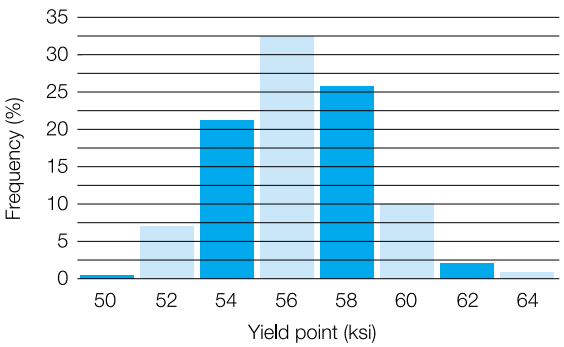
(+70ºF = +21ºC, 10 ft-lbf = 13.55 J)

Flange average Charpy impact value

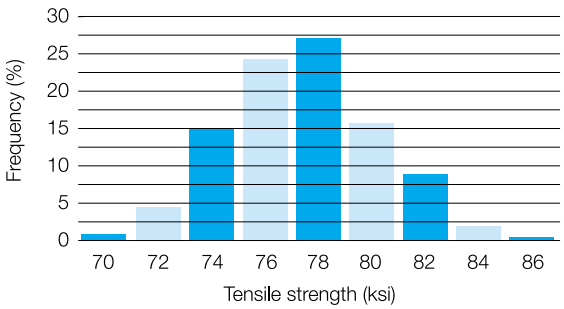


(-4ºF = -20ºC, 10 ft-lbf = 13.55 J)

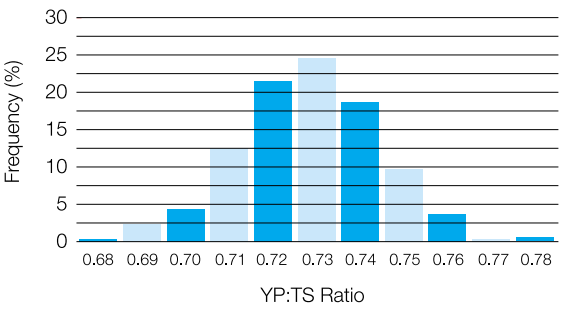
Yield point



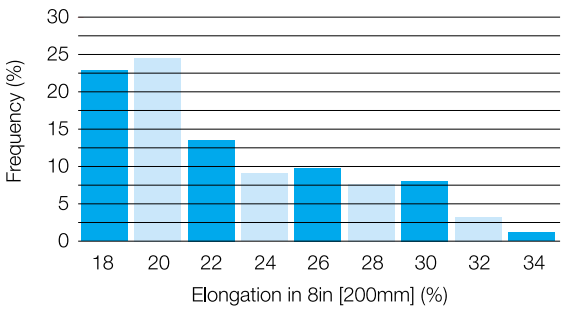
Tensile strength



Yield to tensile ratio

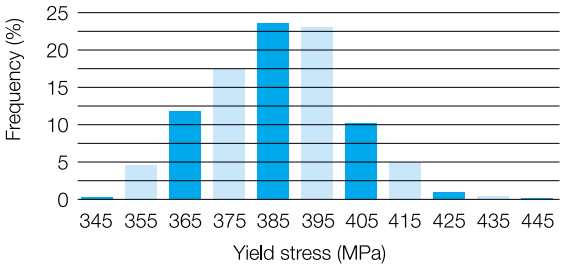


Elongation



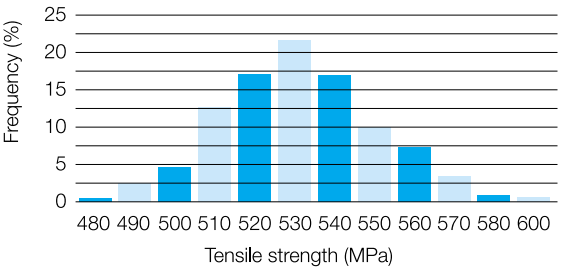
Yield stress

Metric



Tensile strength

Metric



Product range

Section sizes

Jumbo sections can be classified according to the tables below:

Imperial

	Serial Size (in)	Mass per foot (lb)	Depth of section D (in)	Width of section B (in)	Thickness of web t (in)	Thickness of flange T (in)
1	W14 x 16	730	22.420	17.890	3.070	4.910
2	W14 x 16	665	21.640	17.650	2.830	4.520
3	W14 x 16	605	20.920	17.415	2.595	4.160
4	W14 x 16	550	20.240	17.200	2.380	3.820
5	W14 x 16	500	19.600	17.010	2.190	3.500
6	W14 x 16	455	19.020	16.835	2.015	3.210

Metric

	Serial size (mm)	Mass per metre (kg)	Depth of section D (mm)	Width of section B (mm)	Thickness of web t (mm)	Thickness of flange T (mm)
1	356 x 406	1086	569.5	454.4	78.0	125.0
2	356 x 406	990	549.7	448.3	71.9	115.0
3	356 x 406	900	531.4	442.3	65.9	106.0
4	356 x 406	818	514.1	436.9	60.5	97.0
5	356 x 406	744	497.8	432.1	55.6	88.9
6	356 x 406	677	483.1	427.6	51.2	81.5

Other heavyweight beams including W24 x 12¾ (610 x 324mm) are available, in addition to the range outlined above. Please contact Corus for further details.

Requirements for ASTM A992: Standard specification for structural steel shapes

Tensile strength, min ksi, [MPa]	65 [450]
Yield point, ksi, [MPa]	50 to 65 [345 to 450]
Yield to tensile ratio, max	0.85
Elongation in 8in [200mm], min %	18
Elongation in 2in [50mm], min %	21
Core Charpy impact	20ft-lbf [27J] absorbed energy at 70ºF [21ºC]

Total quality

Corus jumbo sections can be manufactured in accordance with ASTM A992, A572 and A36 or to European (EN) specifications. In each case they meet the necessary applicable standards for mechanical properties, chemical composition, surface quality and dimensions. They are based on carefully controlled levels of carbon, manganese, copper, nickel, vanadium and sulphur. For weldability, the carbon equivalent value (CE) is also maintained within specified limits.

Identification and traceability

Each Corus jumbo section carries a bar-coded label, containing order and product details. It allows complete traceability of the section to its cast of origin and its rolling history.

Corus' technical team is at your service

A specially formulated steel

The combination of high strength and good toughness is achieved by using a low carbon, low sulphur micro-alloyed steel, which was developed especially for jumbo sections. As well as having a low carbon equivalent value, the steel's composition is well within the limits specified in A992.

Meeting supplementary requirement S30 of A992

When specified by the customer, Corus can carry out additional testing to certify that the impact toughness performance at the core position meets the supplementary requirement S30 of A992 (Charpy V-notch impact test for Group 3 structural shapes with a flange thickness equal to or greater than 1½ in. (38.1mm) and Group 4 and 5 shapes). Please enquire for details.

Testing the critical core region of the flange-web junction

A comprehensive testing program was carried out to fully characterise the tensile, Charpy impact and fracture toughness properties of jumbo sections, concentrating on the critical subsurface and core regions in the flange-web junction. Table 1 shows the longitudinal, transverse and through thickness tensile properties at these locations in a W14 x 730 section (356 x 406mm x 1086 kg/m) with a flange thickness of 4.9in. (125mm).

Achieving good ductility and toughness

The low sulphur content of the steel ensures that Corus jumbo sections possess excellent ductility in the through thickness (Z) orientation as demonstrated by the high reduction in area value in Table 1 and the histogram in Figure 1.

The flange-web junction was subject to detailed Charpy impact transition testing, with specimen and notch orientations as shown in Figure 2.

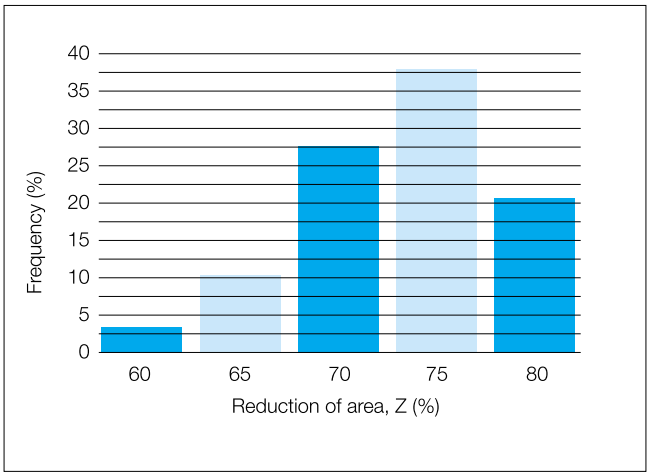


Figure 1: Core through thickness ductility

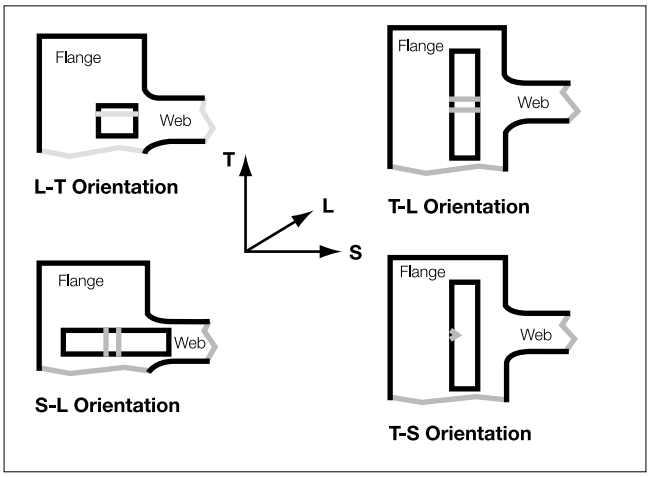


Figure 2: Charpy impact test specimen and notch orientations

Table 1: Tensile properties

Position	Orientation	Yield point (ksi)	Tensile strength (ksi)	YP to TS Ratio	Elongation in 5.65 $\sqrt{S_o}$ (%)	Reduction in area (%)
Subsurface flange back	Longitudinal	51.3	70.2	0.73	30	73
	Transverse	45.5	70.5	0.64	29	76
Core	Longitudinal	50.7	69	0.74	31	75
	Transverse	48.4	67.9	0.71	30	78
	Through thickness	49.3	68.6	0.72	29	76

The results for the W14 x 730 section summarised in Table 2 are generally indicative of the good toughness characteristics of Corus jumbo sections.

Table 2: Charpy impact properties

Position	Orientation (ref. ASTM E399)		Energy Absorbed (ft-lbf)			20 ft-lbf ITT* (°F)
			+32°F	-4°F	-40°F	
Subsurface flange back	Longitudinal	L-T	164	128	102	-67
	Transverse	T-L	137	126	106	-53
		T-S	123	90	38	-49
Core	Longitudinal	L-T	146	127	24	-44
	Transverse	T-L	112	55	10	-13
		T-S	81	30	13	-13
	Through thickness	S-L	90	66	12	-13

* ITT = Impact transition temperature

Further confirmation of these properties was provided by a series of fracture toughness (Crack Tip Opening Displacement) tests on the W14 x 730 section.

The results summarised in Table 3 show that CTOD values in excess of 4 x 10^{-3} in. (0.1mm) were achieved at -4°F (-20°C).

Table 3: Fracture toughness properties

Position	Orientation (ref. ASTM E399)		CTOD (in. x 10^{-3})			
			+32°F	-4°F	-22°F	-40°F
Sub-surface flange back	Longitudinal	L-T	20.0	5.3	-	-
	Transverse	T-L	8.7	5.4	2.6	-
		T-S	10.1	6.7	5.3	3.1
Core	Longitudinal	L-T	18.3	4.6	2.3	-
	Transverse	T-L	26.4	7.4	5.6	2.8
		T-S	19.4	10.9	-	-

Jumbo sections are readily weldable

What's more, with having a low carbon equivalent value they can usually be welded without preheat – providing extra low hydrogen consumables are used.

A low carbon content also means that steel used in jumbo sections belongs to Zone I as shown in Figure 3, making cracking unlikely. If extra low hydrogen levels are used, preheat need not exceed 65°F (18°C) when restraint levels are low. If welding involves higher levels of restraint or higher hydrogen levels, the minimum preheat and interpass temperatures required can be obtained from annex XI AWS D1.1/D1.1M:2002 or from an experienced welding engineer.

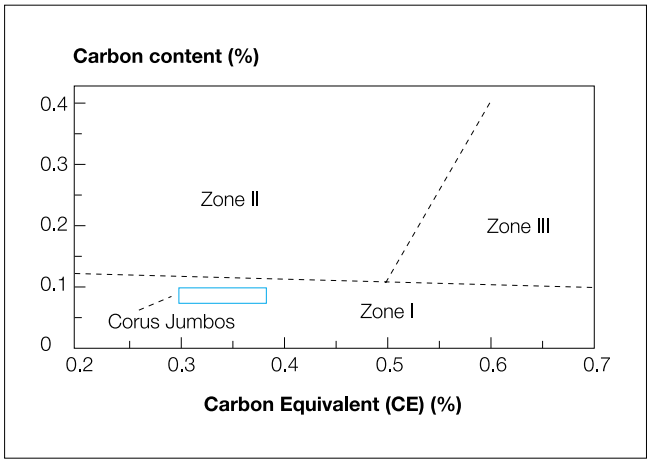


Figure 3: Compositional range for Corus jumbo sections according to AWS D1.1/D1.1M:2002 guidelines on methods of determining preheat

Jumbo sections are often welded at the flange face. When joining beams to columns, for example, complete joint penetration welds may be required. In such welds, the toughness of the weld and heat affected zone (HAZ) may be of interest, especially if there is a seismic loading requirement. HAZ toughness was determined following the production of test welds in which large beams were welded to the flange face of a jumbo section.

Through using a steel which has both a low carbon content and a low carbon equivalent value, the Charpy impact tests made on the HAZ of the test welds showed a very high impact toughness (see Figure 4), well above the minimum value needed for the base metal of 20ft-lbf (27J) at 70°F (21°C).

After witnessing some weld failures during the Northridge earthquake, a weld Charpy requirement of 20ft-lbf at 0°F (-18°C) was suggested as an appropriate service requirement for welds. The results show that all tests on the weld and HAZ well exceeded the 20ft-lbf requirement and were unaffected by welding with or without preheat.

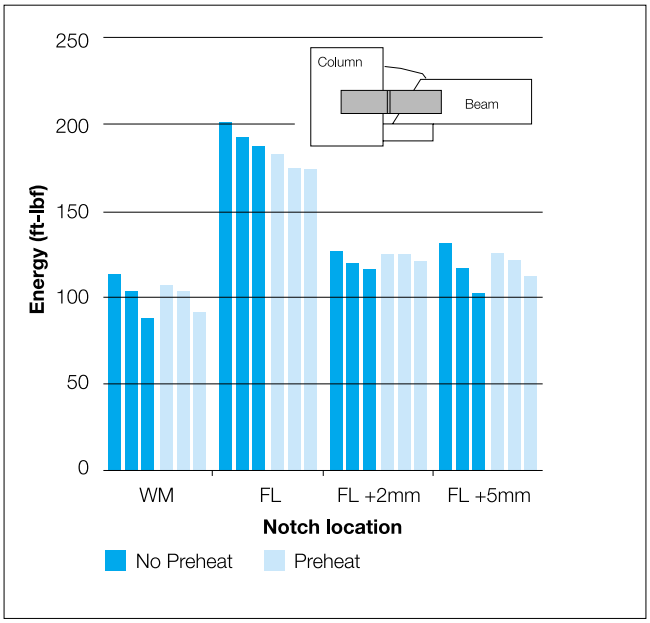


Figure 4: Charpy impact test results for a W14 x 730 section welded by the SMAW process (test temperature -4°F (–20°C) for weld and 70°F (21°C) for HAZ/parent).

Welding fabrication specifications sometimes set limits on the maximum hardness levels in the HAZ. In view of the lean composition of the low carbon micro-alloyed steel, high HAZ hardness values are unlikely.

How research and development in the USA shaped our thinking

Corus played an integral part in the SAC program (Structural Engineers Association of California, Applied Technology Council and California Universities for Research in Earthquake Engineering), a joint venture set up to investigate the performance of materials and systems subject to earthquake loading.

Extensive research into the properties of jumbo sections – involving a series of punishing tests – was undertaken as part of this program. Working with SAC also gave us a detailed knowledge of A992, the ASTM standard for structural shapes for use in building framing.

An example of a performance test is shown in Figure 5.

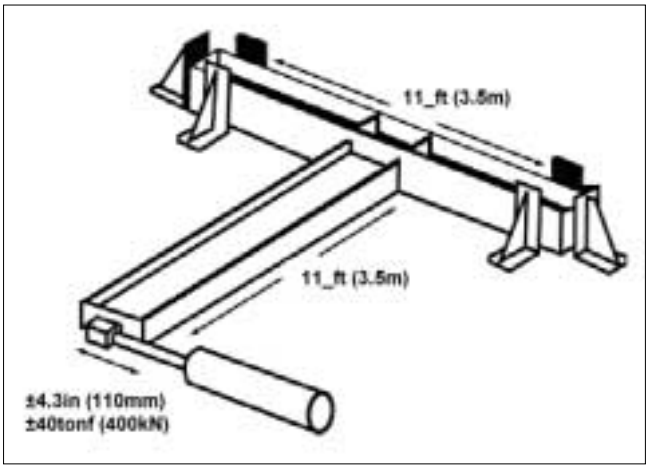


Figure 5: Section cyclic loading seismic test

Structural performance

As well as ensuring strength and toughness, Corus also places great emphasis on the structural performance of its jumbo sections when used in areas of seismic activity. Figure 6 shows the type of research that Corus may be able to offer customers to help determine whether core testing is appropriate. In this example regional seismic hazard ratings were provided for a client who was examining the feasibility of a power station project in the state of Ohio.

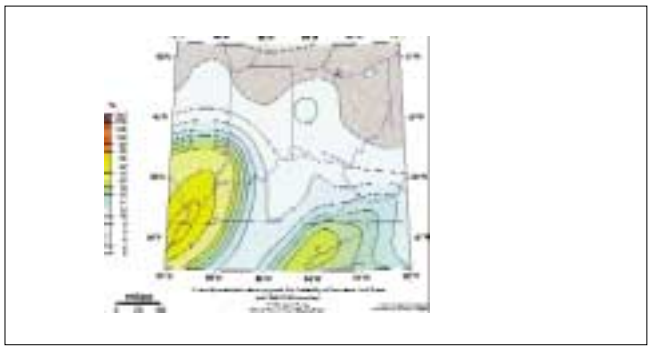


Figure 6: Seismic hazard map

As well as the SAC program, further testing was carried out to assess the overall performance of Corus' jumbo sections in the most severe loading conditions. These included the following investigations:

Resistance to tearing during welding

Over thirty structures were fabricated using Corus jumbo columns and beams to evaluate resistance to tearing during welding under the most severe restraint conditions (Figure 7). After fabrication each weld was fully examined using non-destructive and destructive test techniques to detect the presence of any tears.

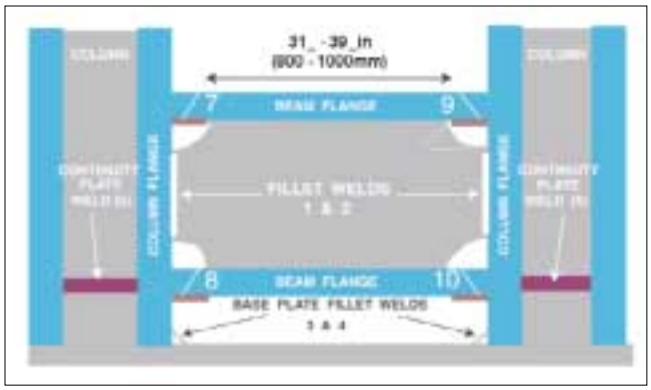


Figure 7: Schematic of fabricated structure

Right
Test weld being produced

Through flange thickness fracture

Strong steel plates were welded to jumbo column flanges to enable very high stresses to be applied in the through thickness direction (Figure 8). Stresses and strains far in excess of the column's yield point were achieved and in some cases the maximum load capacity of the test machine was reached before failure of the welds.

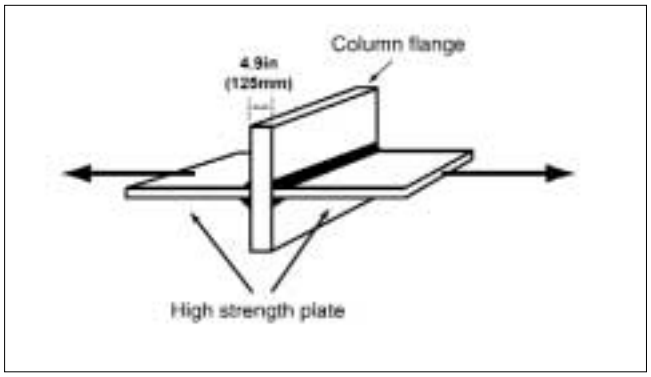


Figure 8: Through flange thickness stress test

Modelling of stresses in joints

Finite element analysis of different beam-column joint designs was carried out to determine the severity of the stresses that might be applied to different parts of the connection during an earthquake – an example is shown in Figure 9. This information can be used to ensure fitness for purpose of the steel, the weld metal and the connection design.

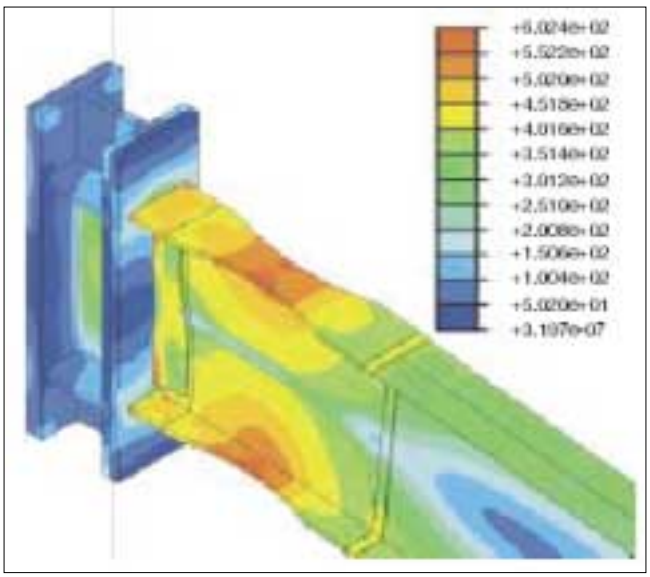


Figure 9: Stresses in a 'dogbone' connection

The results from the SAC program and Corus' own testing have proven that Corus jumbo sections should be your first choice for any large-scale construction project anywhere in the world.

The next step

We are always pleased to give advice on design and product selection. If required this can include advice on the seismic and metallurgical aspects of construction.

Please contact us if you have any queries about any of the issues raised in this brochure, or contact your local sales office.

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