Fire-Safe Design in Buildings Using Fire-Resistant Steel without Fire Protection

Steel-frame fire-resistant buildings which omit the fire protection for columns and beams have been appearing in various places in Japan owing to the adoption of fire-resistant (FR) steel, which guarantees yield strength at high temperature. Above all, the number of multistory car parks adopted that satisfy specified conditions has greatly increased because it has become possible to acquire approval for buildings without fire protection (un-protected, hereinafter) through the usual application procedures for confirmation, though fire-safe design is necessary. It is expected that FR steel, which is in line with the movement of making a performance code for the Building Standards Law, will increasingly continue developing in the future.

1. Characteristics

Possible un-protected columns and beams are those whose temperature remains below 600°C when exposed to fires and are: (1) columns and beams in open car parks, (2) outdoor columns and beams (outside steel frame) on which indoor and neighboring fires have small effect, (3) columns and beams within playing section and stands in sports facilities, (4) columns and beams in atriums and lobbies, and (5) other uses such as columns and beams within ascending/descending passages in building construction.

1) Realization of economical structure design

The quality feeling of steel frame is made good use of, and light and colorful sports facilities or atriums are being built with the frame displayed as part of construction design.

2) Unnecessary measures to prevent falling off from protected steel

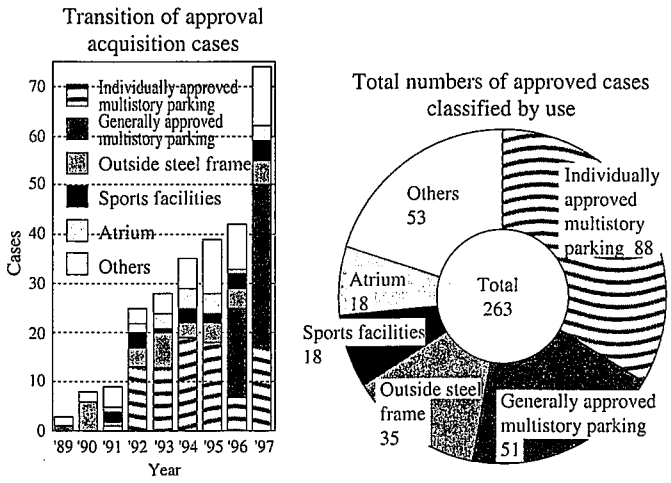
The problem that falling off from protected steel due to age deterioration, vibration, wind and rain can be drastically solved.

3) Maximum use of space

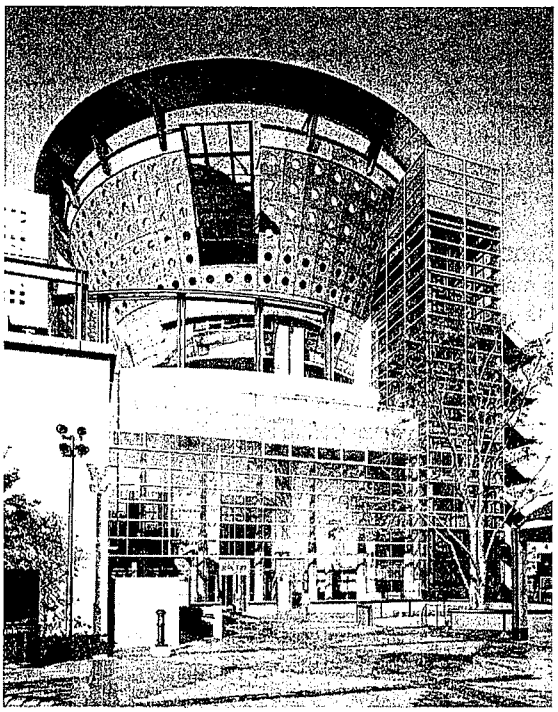
There is more space around columns and under floors, expanding the freedom of designing such construction facilities as ventilation ducts. In some cases, more space has been linked to higher stairs and smaller construction area.

4) Reduction of costs and work periods

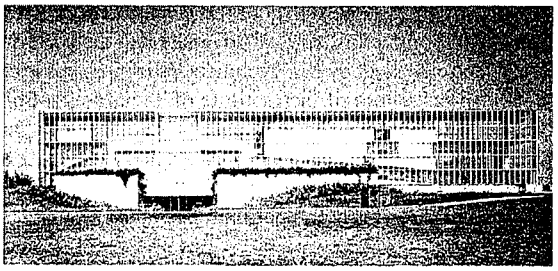
The above results enable the reduction of construction costs and unneeded work periods for fire protection.



The approval acquisition results of FR steel by Nippon Steel Corporation



Nakasan Hirosaki Shop (adopted for the columns and beams of the entrance see-through elevator)



View Rest House in Kasai Seaside Park (adopted for the columns and beams of the walls)

2. Approval

FR steel is the only steel product for building structures which guarantees yield strength at high temperature and assures that the yield strength (0.2% offset) at 600°C is more than two-thirds of the specification value at normal temperature (the actual value is listed on the mill sheet). For this reason, the lower limit yield strength of frame (the critical yield strength with no other lower values at least) from normal temperature to 600°C can be calculated. So in the same way as the usual antiseismic design, the safety of frame in the presence of fires can be verified (design against fire).

To approve un-protected frame by adopting FR steel, this verification of safety with the design resistance to fire is a major premise.

(1) Un-protected frame by individual approvals (the 38th article approval) by Minister of Construction

For general buildings, each building is designed to withstand fire and is examined by the disaster-preventive performance rating committee in Japan Construction Center, then un-protected steel can be

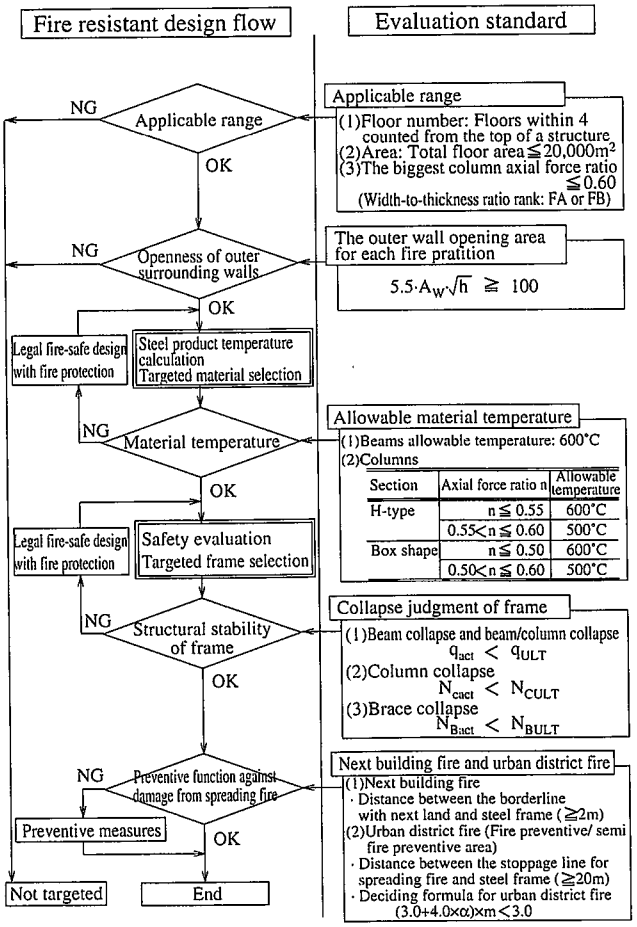
approved by applying for approval by the Minister of Construction based on the examination results.

(2) Un-protected open car parks by the application of general approvals

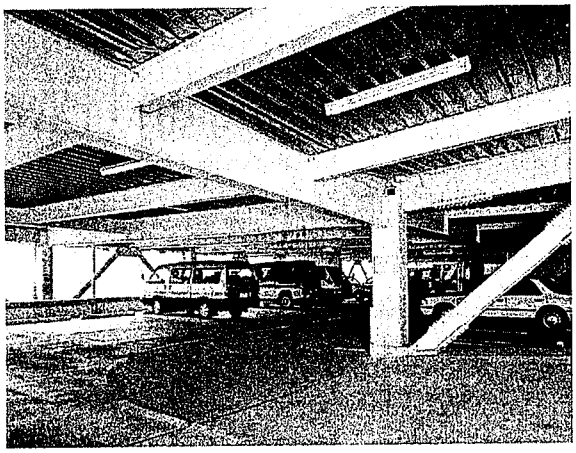
Such parking lots as satisfy the application conditions of "Fire-safe design in buildings using un-protected FR steel in open car parks" have acquired general approval by Japan's Minister of Construction concerning the technical standard and quality control. The approval of un-protected steel can be obtained once a fire-safe design catalog is submitted to the specific administrative agency at the time of construction confirmation application. No rating by Japan Construction Center or application for approval by Minister of Construction is necessary.

Application conditions for "Fire-safe design in buildings using un-protected FR steel in open car parks"

Outline (Floors, Scales)	Parking lot Parking lot Parking lot Parking lot Shops, etc. Floors within 4 counted from the top Less than 20,000m² in total targeted floor area Steel frame Column axial force ratio≦0.6
Use	Open car parks for passenger cars
Ranges of un-protected frame	(1)Columns, beams and braces within the parking lot area (2)Columns, beams and braces in elevator halls, staircase rooms and rest rooms accompanying parking lots
The limitations on the floors and scales are to be abolished in the near furture	



Fire resistant design flow and evaluation standard



Sky parking (adopted for the columns and beams of the parking lot)

3. Materials

The FR steel is given superior fire-resistance by the addition of such alloying element as molybdenum to a base steel. Chemical compositions or the mechanical properties of the base steel at normal temperature satisfy the standards of steel for various construction structures like the thick plates or H-shapes of the SN Specification or the steel tubes of the STK Specification. For this reason, antiseismic or windproof designs are possible as prescribed in the Building Standards Law, and there is no need for special structural approvals, e.g. steel structural grading.

The fire-resistant performance of the joints can be secured by using high-strength bolts and welding materials for the FR steel.

Kinds and types of FR steel

Steel type	Kind		Specification code	Adopted thickness(mm) (Outer diameter for steel tube)
Plate	General		NSFR400B, C NSFR490B, C	More than 6, less than100 More than 6, less than100
	Weather resistant specifications		NSFR400B, C-W NSFR490B, C-W	More than 6, less than100 More than 6, less than100
Square pipe	U column		STKR400FR (STKR490FR)	More than 6, less than 16
	U column W C column		NSFR400B, C NSFR490B, C NSFR400B, C-W NSFR490B, C-W	More than 12, less than40 More than 12, less than40 More than 12, less than40 More than 12, less than40
H-shapes	General		NSFR400B, C NSFR490B, C	Less than 40 Less than 40
CT-shapes	General		NSFR400B, C NSFR490B, C	Less than 40 Less than 40
Tube	Seamless tube		NSFR400-TK NSFR490-TK	ϕ 165.2 - 406.4 ϕ 165.2 - 406.4
	Steel tube with large diameter	UO tube	NSFR400-TK NSFR490-TK	ϕ 457.2 - 1,422.4 ϕ 457.2 - 1,422.4
		Spiral tube	NSFR400-TK NSFR490-TK	ϕ 400 - ϕ 400 -
	Electric welded tube		NSFR400-TK NSFR490-TK	ϕ 42.7 - 406.4 ϕ 42.7 - 406.4
Angle	General		NSFR400B	L – 65 × 65 × 6 L – 75 × 75 × 9 L – 90 × 90 × 10
Channel	General		NSFR400B	– 125 × 65 × 6 × 8 – 150 × 75 × 9 × 12.5

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