Technical Report

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Transition of Light-Gauge Steel Framed Houses and Development of Four-Story Steel-Structured Housing Method

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Abstract

In November 2001, light-gauge steel framed houses were legislated under a Building Standard Law in Japan as a new structural system. In September 2012, the notification was revised. Then, as for the light-gauge steel framed houses, limit of the number of stories is relaxed, blended structure with other structure is enabled, and design flexibility is extended. With notification revision, we had developed the original steel-structured housing system, realized 3- storied and 4 storied houses at last, by developing high strength bearing wall and joining hardware, improving fireproof performance of membrane.

1. Introduction

The steel-framed house, which represents the light-gauge steel-framed house (**Photo 1**), has received high appreciation and recognition from the market and customers owing to the structural performance and the fireproof and fire-resistance performance and through the development to secure and improve heat-preserving and energy-saving performance by means of the external thermal insulation and ventilation system. The steel-structured housing system is a highly competitive construction system owing to the high quality realized by the factory-produced panels, reduced on-site construction period, and so on.

In this article, the feature of the steel-structured housing system, which was mostly developed by steel companies, is described first. In the second place, the outline of the legislation and the revision of the technical standards of the light-gauge steel-framed house is discussed (Notification in the year of Heisei 13 of the Ministry of Land, Infrastructure, and Transport, No. 1641), legislated aiming at diffusion of the steel-structured housing system to low-rise building market. Further, the following are introduced: the steel-structured housing system of three- and four-storied construction that Nippon Steel & Sumitomo Metal Corporation has solely developed in parallel with the development of the abovementioned notification, and the official certification obtained aimed at enhancing the conveniences in application procedures of design and building certification.

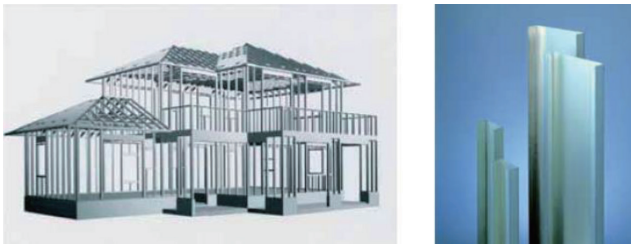

Photo 1 Steel framed house and light-gauge shaped steel

2. Features of Steel-structured Housing System

As shown in **Fig. 1**, the steel-structured housing system is a system wherein the frames which are made from wooden members of "the two-by-four wood frame construction method" (two by four) is replaced by surface-treated light-gauge shaped steel of thickness of approximately 1.0 mm, forming a wall panel and a floor panel by fixing a structural facing board such as plywood board and gypsum board to the framework with self-drill screws and fabricating a house with these panels as if assembling a box.

In **Fig. 2**, a typical exterior wall used in the steel-structured housing system and the internal structure of the wall frame are shown. The structural frame is composed of panels, each of which consists of light-gauge shaped steel and structural facing boards fastened to the shaped steel with self-drill screws and the "external

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thermal insulation and ventilation system" that covers the entire external side of the housing space with a thermal insulating material and a ventilation layer is employed as the standard specification. Furthermore, on the external side, a membrane of ceramic-based exterior wall and on the internal side, a membrane of gypsum board is arranged, respectively. The integrated function of the light-gauge shaped steel, structural facing board material, thermal insulating material, and membranes exerts high-level performance of structural function, fireproofness and fire resistance, thermal insulation, sound insulation, and so on, all of which are required to houses.

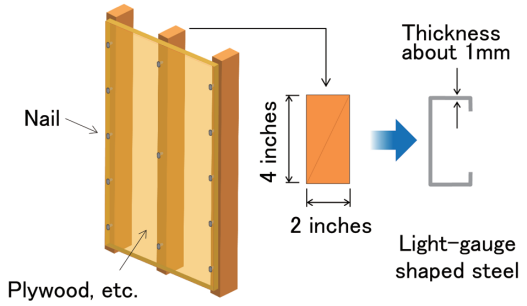


Fig. 1 2×4 wooden frame and light-gauge shaped steel

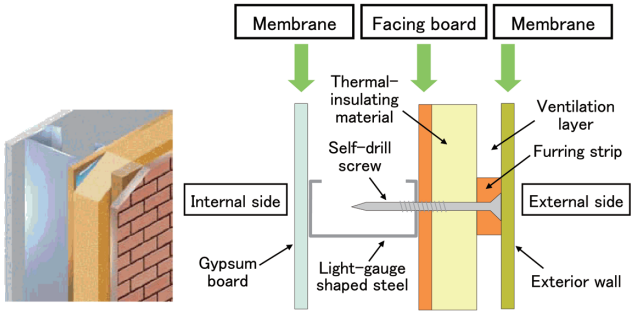


Fig. 2 Exterior wall structure of steel framed houses

Photo 2 Scene of structural panel production in factory

Photo 3 Jointing method for structural panel with self-drill screw

As shown in **Photo 2**, the structural panel is produced in a factory, and the structural panels are connected to each other with self-drill screws on-site as shown in **Photo 3** and the on-site construction work is made easy. Furthermore, the on-site construction man-hours are less, and therefore, the construction in a short period is possible and accordingly, the system is cost competitive.

3. History of Technical Standard Concerning Light-gauge Steel-framed Houses

The adoption in November of 1994 as one of the themes of the Urban Steel Study Group under the auspices of the then Iron and Steel Division of the Basic Industries Bureau of the Ministry of International Trade and Industry was the historical first step for the steel-structured housing system in Japan. In **Table 1**, the transitions of the technical standards and the legislation [1] are shown.

In January 1995, the Great Hanshin Earthquake took place and about 3 000 imported steel houses were built among 50 000 temporarily constructed houses for restoration and, even thereafter, as the number of applications for certification were sent from overseas, in July of the same year, the then Ministry of Construction announced "Standards for Rating and Evaluating Steel-framed Houses" [2] and construction of houses based on the special authorization of Minister of Construction (authorization as per Article 38 of former Building Standards Act) became possible. Following the announcement,

Table 1 History of technical standards and laws fixed for steel framed houses

1994	Steel frame construction method was taken up as one of the themes of a meeting of Urban Steel Society.
1995	The Great Hanshin Earthquake Standards announced for Rating & Evaluating Steel-Framed Houses.
1996	Kozai Club (KC) establishes Steel-Framed House Committee.
1997	KC obtains approval of the Minister of Construction based on Article 38 of former Building Standards Law.
1998	KC-type develops steel-framed houses.
2000	Enactment of Japan's Housing Quality Assurance Act Revising of The Building Standards Law Revision of Article 38 pertaining to KC-type steel-framed houses.
2001	Notification issued on light-gauge steel-framed houses. [Steel-framed houses officially recognized as a type of steel framed construction.]
2002	Article 1-3 of the Enforcement Regulations provides for the approval of the Minister of Construction for KC-type steel-framed houses.
2007	Revision of the Building Standards Law [More stringent structural design, examinations and inspections.]
2012	Revision of the notification on light-gauge steel framed houses [Limit of the number of stories is relaxed, blended structure with other structure is enabled.]

in January 1996, six iron and steel companies (Kawasaki Steel Corporation, Kobe Steel, Ltd., Nippon Steel Corporation, Sumitomo Metal Industries, Ltd., Nisshin Steel Co., Ltd., NKK Corp.) established the Committee of Steel-framed House with the Kozai Club (an incorporated body, current Japan Iron and Steel Federation (a general incorporated association)) acting as the secretariat and started full scale research on durability, thermal insulation properties and sound insulation properties in addition to the structural performance and fireproofness and fire-resistance properties. Full-scale sales of house merchandize of the two-storied detached houses of Kozai Club type (hereafter called as KC type) based on the steel-structured housing system was started in 2000 and the recognition in the market jumped instantly.

On the other hand, in November 2001, a notification of "Technical standards required from safety aspect pertaining to the structuring method of the light-gauge steel-framed construction or the structural section of a construction" was enacted by the Ministry of Land, Infrastructure and Transport and the light-gauge steel-framed houses was officially recognized by the Building Standards Act and incorporated thereto as a steel-framed construction, and constructions of three stories or below came to be permitted to be designed on the ultimate horizontal resistant force. Owing to this notification and the adoption by major housing makers, the number of buildings that started construction in 2005 grew to as high as 2 157 (about 20 000 houses)[3] as shown in **Fig. 3**.

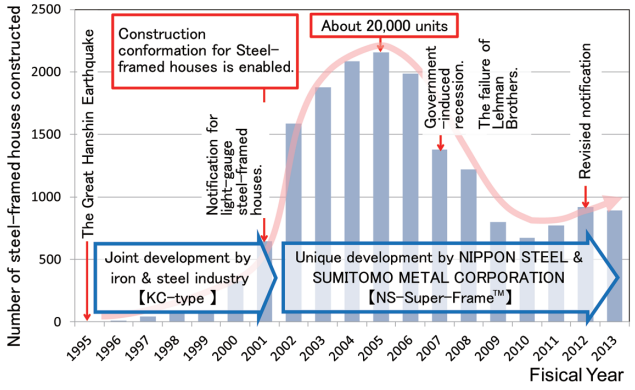


Fig. 3 Expansion in number of steel framed houses constructed in Japan

Following the examination of applications for building certificate toughened by the revision of the Building Standards Act in 2007 and, affected by the business recession caused by the economic downturn precipitated by the Lehman Brothers bankruptcy in 2008, the number of construction of residential housing use decreased drastically, however, with the emergence of new type steel-structured buildings like three-storied construction realized by the notification and, one-storied shop and, owing to the drastic increase in nonresidential use buildings like health and welfare facilities for aged people, shops and, continued adoption by companies for use as company houses and dormitories, more than 700 buildings have been continuously built every year since 2011.

The Japan Iron and Steel Federation, aiming at enhancing the freedom of designing of light-gauge steel-framed houses and at further spreading, continued the research on the relaxation of the restriction imposed on the number of stories and the practical use of structures combined with other structures and appealed the revision of the notification to the Ministry of Land, Infrastructure, Transport and Tourism. As a result, the notification of the revision[4] was announced and enacted in September 2012. With this, designing of the following constructions on the basis of horizontal load bearing capacity has become possible[5]; four-storied light-gauge steel-framed houses as shown in **Fig. 4** and construction of structures combined with other structures like the case, for instance, where the aseismic structure members of the light-gauge steel-framed houses are replaced with steel-framed structures and reinforced concrete structures.

4. Development of NS-Super-Frame™ and its Application

4.1 Evolution from two-storied construction to three-storied construction

In 2001, when the notification pertaining to the light-gauge steel-framed houses was announced, aiming at widely spreading the steel-structured housing system that exerts high housing performance to the low-rise building market and, as its own steel-structured housing

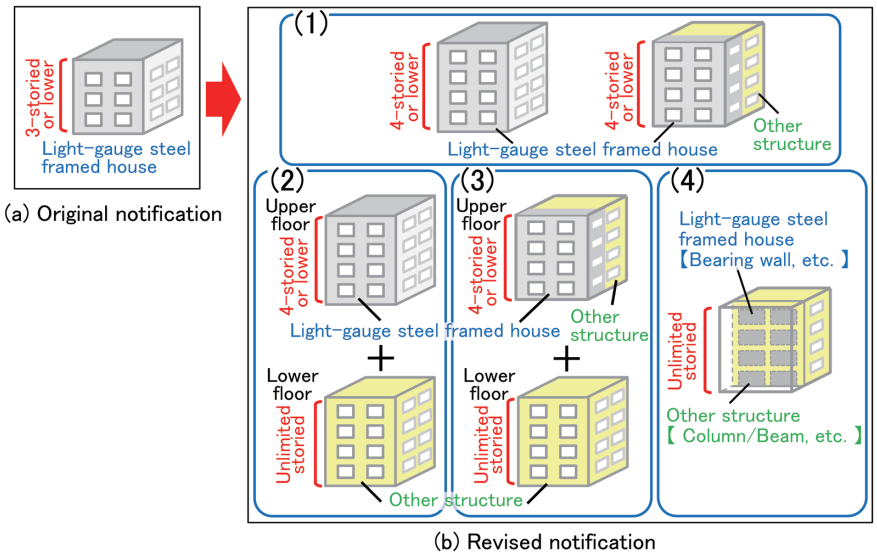


Fig. 4 Summary of notification revision for light-gauge steel framed houses

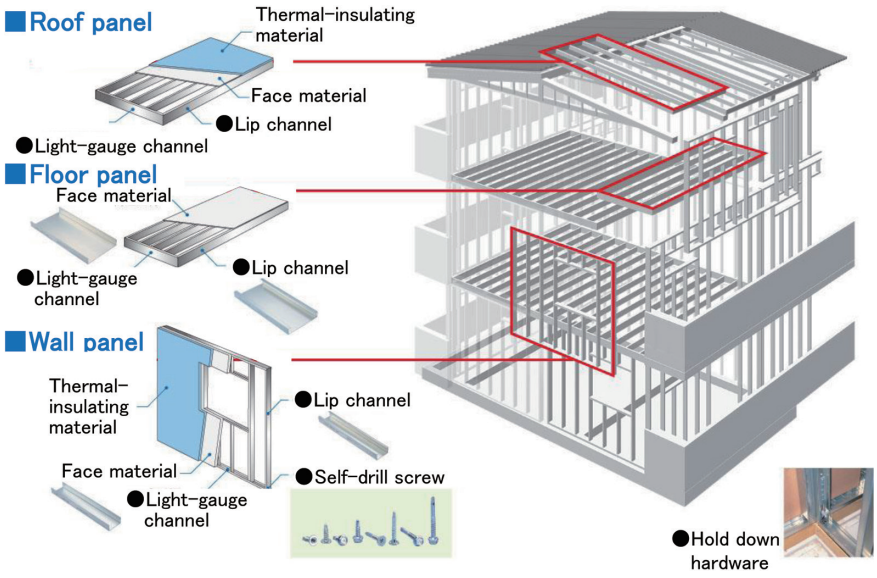


Fig. 5 Structural system of "NS-Super-Frame™"

Photo 4 Scene of fire-resistive performance test with exterior wall using ceramic-based board

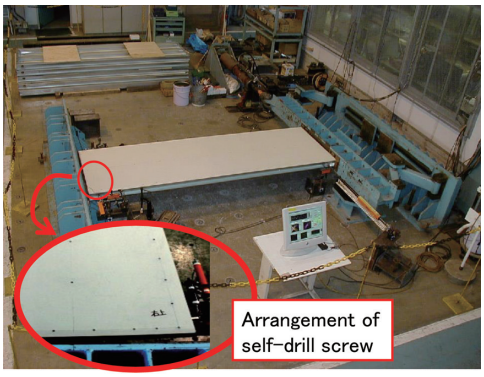


Photo 5 Bearing wall for 3 stories using ceramic-based board

system, the then Nippon Steel started the development of the NS-Super-Frame™ as shown in **Fig. 5** (hereafter called NSSF construction system). Aiming at realization of practical application of "one hour fire resistance for three-storied construction," which the KC type failed to achieve, the then Nippon Steel developed member materials from the fire resistance and structural aspects. Selected as the structural facing material was the ceramic-based board, which is superior to wooden material in fire-resistance performance and higher in rigidity and strength. The reasons are; it is difficult to secure the 1 h fire resistance when the flammable wooden material is used for the structural facing board, and furthermore, "the seismic force in the horizontal direction acting on the first story bearing wall of three-storied construction" becomes twice or larger of that of two-storied construction.

Furthermore, by optimizing the material, board thickness and the lamination composition of the membranes such as the exterior wall that covers the entire house and the gypsum board on the internal side, and by improving therewith non-damage characteristics against a fire, thermal insulation properties and smoke insulation properties, a fire-resistant structure that maintains the 1 h fire resistance (**Photo 4**) has been realized. Furthermore, by optimizing the number of the self-drill screws used for fixing the ceramic-based board and the gypsum board to the frame of the light-gauge shaped steel, a bearing wall excellent in rigidity, bearing strength and deformability performance (**Photo 5**) was developed and the amount of the bearing wall per unit floor area could be suppressed to the level equal to that of two-storied construction.

Furthermore, since the steel-structured housing system is a platform construction system where the wall panel and the floor panel are piled up alternately, the axial force developed in the vertical frame of a bearing wall by an overturning moment acted upon by seismic force and or wind pressure is transmitted to the lower floor wall via the floor panel. Conventionally, the rigidity in the thickness direction of the structural facing board installed on the floor panel is low and further, there is a minute gap between the floor joist of light-gauge shaped steel and the reinforcing hardware, and when the axial force is directly transmitted to the floor panel, the floor local deformation as shown in **Fig. 6** (a) takes place. Consequently, the rotation at the foot of a bearing wall is accumulated as shown in **Fig. 7** and it becomes difficult to suppress the story deformation angle of the upper stories to within the control criteria value provided in the Building Standards Act. For this reason, in the NSSF construction system, as shown in Fig. 6 (b), the story deformation angle was successfully satisfied by developing and applying a high rigidity bypass hardware that enables the transmission of an axial force by

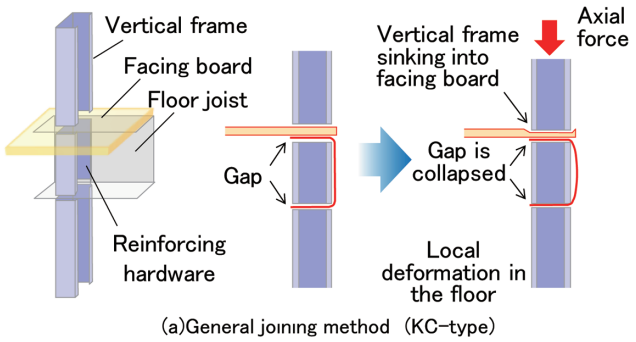


Fig. 6 Axial load transmission system to bearing walls, floor below, and foundation

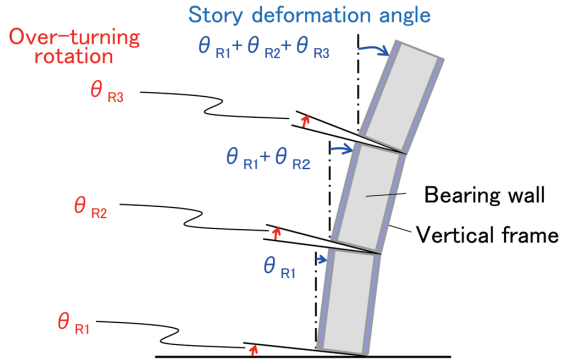


Fig. 7 Effect of over-turning rotation of multistory bearing wall

joining the vertical frames of the upper and lower bearing walls directly with a compression bolt, not via the floor panel.

The three-storied dormitory for foreign students in Kitakyushu City (**Photo 6**)[1] was the first three-storied construction project built by NSSF construction system in 2004. As compared with reinforced-concrete structure, the weight of the upper framework becomes light to one third and the construction without pile is possible if the bearing capacity of soil allows and the construction period can be shortened to two thirds. Furthermore, as light-weight shaped steel is used for the structural framework, the depreciable life is short of 19 years as per tax law, unlike 34 years of steel-structured buildings and 47 years of reinforced concrete buildings, the economic advantage of reduced cash-out on the part of building owners is also brought forth. Such superiority has come to be recognized in the market and the system has come to be incessantly employed and the case of actual employment has increased steadily with applications to urban-type apartment houses on a very narrow space, company houses and dormitories of enterprises in addition to those of Nippon

Photo 6 3-story dormitory for foreign students in Kitakyushu City (60-minute quasi-fire-resistant building) (completed in March 2005)

Photo 7 3-story restoration public housing in Kamaishi, Iwate (1-hour fire-resistant building) (completed in March 2013)

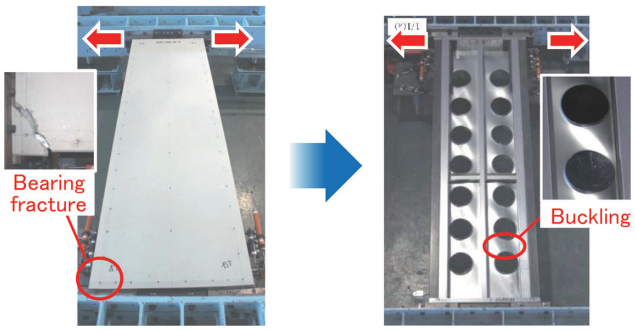
Steel & Sumitomo Metal, health and welfare facilities for aged people, the restoration public housing as shown in **Photo 7**, and so on.

4.2 Evolution to four-storied construction

In parallel with the move of relaxation of the restriction imposed on the number of stories according to the revision of notification announced in 2012, Nippon Steel & Sumitomo Metal and NS HI-PARTS CORPORATION promoted the development of structural framework for practical application to four-storied construction, intending practical use in the market of medium-rise housing buildings that are required by the needs to effectively utilize a piece of land. Since the horizontal seismic force acting to the bottom story of four-storied construction becomes 1.6 times higher than that of three-storied construction and the axial force developed by overturning moment becomes nearly two times higher, creation of members of framework (bearing wall, joining hardware and vertical frame) of further higher strength became indispensable.

In the first place, the structural board material of the bearing wall was drastically restudied. In case of the structural facing board material (ceramic-based facing board) of the bearing wall of three-storied construction as shown in **Photo 8** (a), the bearing strength can be improved by increasing the number of self-drill screws, however, the deterioration in bearing strength after the maximum bearing strength is reached is remarkable and the energy absorption capability is limited to be secured. For this reason, a galvanized steel sheet of about 1 mm in thickness was employed as the structural facing board material for the bearing wall of four-storied construction. With the cooperation extended by Nagoya Institute of Technology[6, 7], the optimized form to make the best use of its rigidity and deformability was sought after.

To be specific, the deformability was devised to be improved by arranging a pluralities of apertures each provided with a bar ring (hereafter called as bar ring aperture) as shown in Photo 8 (b) so as



(a) Ceramic wall for 3-story building (b) Steel wall for 4-story building

Photo 8 Destructiveness of bearing wall

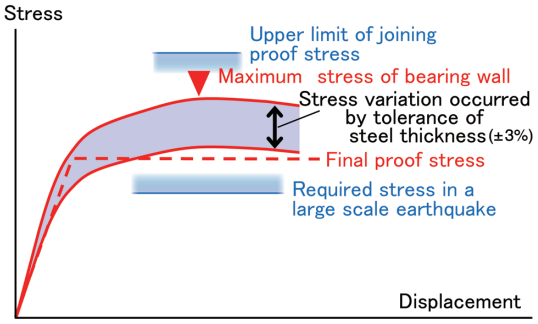


Fig. 8 Relationship between steel sheet thickness and proof stress of bearing wall

to further restrain the deformation of the outer surface of the steel sheet and by developing shear buckling on the inter-aperture flat area of the steel sheet while maintaining the resistance strength in case acted upon by a heavy load. However, when the maximum bearing strength of the bearing wall becomes excessive, the axial force developed by the overturning moment acting on the joining hardware and the frame also increases and the preservation of the axial force by the section of the light-gauge shaped steel (hereafter called joining of possessed bearing strength) becomes difficult. For this, as shown in **Fig. 8**, the thickness tolerance of the structural facing board (steel sheet) that is considered to exert influence on the bearing strength is controlled to be within ±3% and the increase in the bearing force after its arrival at the ultimate level of the bearing strength of the bearing wall was suppressed. With this, high rigidity and high strength were realized at primary seismic design and the improved energy absorption capability and the joining of possessed bearing strength were realized at secondary seismic design. Furthermore, as the arrangement and the diameters of the bar ring apertures are designed, taking into account the equipment layout of pipes that go through the bearing wall and connecters, the installation of equipments can be conducted with ease by utilizing the apertures (**Photo 9**).

Furthermore, as for the hardware that joins the upper floor bearing wall and the lower floor bearing wall, the concept of the axial force transmission mechanism of the by-passing hardware used for the three-storied construction was inherited. However, since it is self-explanatory that there is a limit for the compression bolt to retain the axial force, a method of transmitting the axial force was developed in which a box-type hardware having enlarged sectional area to provide higher compressive resistive strength was incorporated to the floor panel. In the early stage of the development, the box-type hardware was built up by welding heavy plate pieces. However, aiming at reducing the cost by eliminating the welding and by making the form compact, an integrated single-piece hardware of high rigidity and of high strength as shown in **Photo 10** was realized by working out the optimized form under the cooperation of a cast-products manufacturer (HINODE, Ltd.). A joining mechanism, which can sufficiently withstand the turnover axial force acting onto the bearing wall, was established by joining with bolts the box-type hardware and the hold-down hardware equipped at the end of the vertical frame of either upper bearing wall or lower bearing wall.

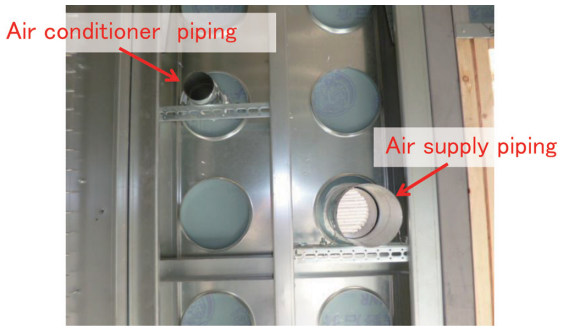


Photo 9 Facilities plumbing placement to the bar ring aperture

Photo 10 Box form hardware made by cast steel

Furthermore, as the vertical frames arranged at both sides of the bearing wall are subject to the axial force identical to the one acting onto the joining hardware, the sectional area had to be enlarged to retain higher compressive resistive strength. In order to take advantage of the depreciable life of 19 years, a vertical frame member with high resistive strength against high axial force was realized, while suppressing the thickness of the shaped steel sectioned hardware of the vertical frame to below 3 mm, by combining more than one of box-shaped steel and lipped shaped steel both of which have high buckling resistive strength against compression. Furthermore, as to the fire-resistance performance, 1 h fire-resistance structure was established by applying and further developing the fire-resistance performance optimization technology of the membranes established during the development of the three-storied construction.

The abovementioned development of the member materials in terms of structure and fire resistance allowed the light-gauge shaped steel-framed four-storied construction to be realized.

4.3 Optimization study on practical application to four-storied construction and application to in-company company houses

As the structure framework of the four-storied construction is different from the existing one of the three-storied construction, upon practical application, there are a number of problems that in-

ternally exist and cannot be grasped merely with desk work study. Therefore, aiming at enhancing the degree of perfection of the outcome of the abovementioned development and the smooth transfer to practical application to actual construction, the three designing and construction companies of NIPPON STEEL & SUMIKIN TEXENG.CO.,LTD., NS HI-PARTS, and Nippon Steel & Sumitomo Metal established a joint development organization and made efforts to extract problems and to tackle solution of such problems from the standpoint of "spirit of manufacturing" in the areas of designing, material development, manufacturing, and construction.

To be specific, a four-storied experimental building as shown in **Photo 11** was built in the company research and development institute (in Futtsu-city, Chiba Prefecture) and various verifications were executed to extract subjects to be improved as to foundation work, manufacturing of panels and erection in addition to designing of structure, fire resistance, thermal insulation, and sound insulation. About more than 100 subjects were clarified which include the method of setting foundation anchor bolt to the correct position, measures to hang and install wall panels of a weight 1.5 times larger than that of the conventional wall, the method of installing the newly developed hardware that connects the upper and lower bearing walls, the fixing method of thermal insulation and external wall material, and so on. The three companies repeated studies on optimization and worked out solutions. The knowhow so obtained was arranged in the forms of finalized standard drawings, manuals, and specification documents, and a surely reliable designing and construction system has been established.

Photo 11 4-story experimental building

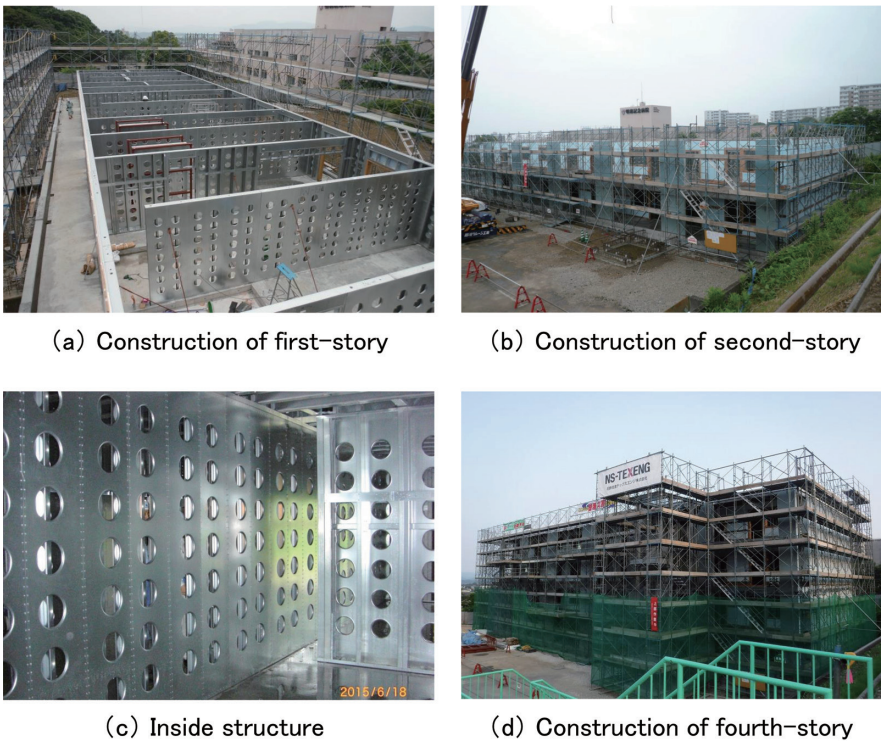
The first project in Japan of the four-storied construction is the apartment houses in Akenokita for employees of Oita Works of Nippon Steel & Sumitomo Metal (**Photo 12**). Under the support of the abovementioned joint development organization, the construction was started in March 2015, progressed smoothly, and the project was completed in November of the same year.

4.4 Various public certifications

4.4.1 Structure-related matter

Aiming at improving the conveniences by further simplification of the designing method of NSSF construction system and the building certification application, the two companies of Nippon Steel & Sumitomo Metal and NS HI-PARTS have obtained various public certifications jointly (**Table 2**) and have continued to maintain them. The structural member parts and the design standards underwent a stringent technical examination of The Building Center of Japan (a general incorporated association) and the two companies have obtained the rating and the authorization corresponding to the number of stories and the purpose of usage.

As for the construction of "three-storied or below," the two com-

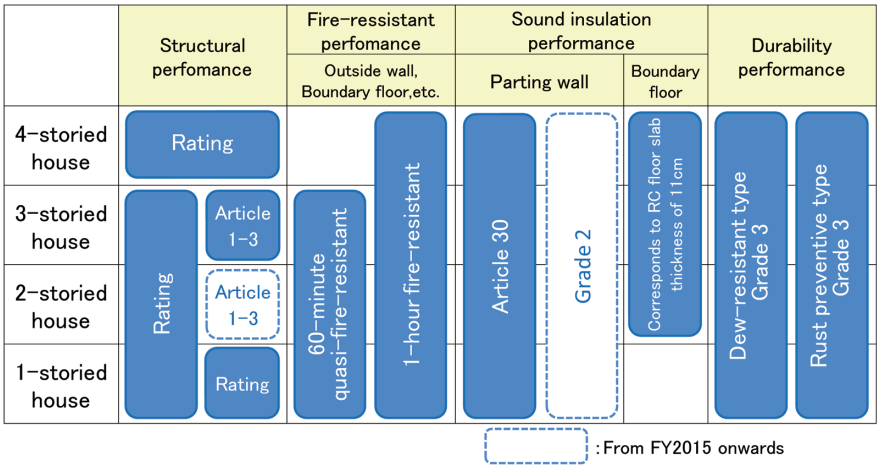


(a) Construction of first-story (b) Construction of second-story

(c) Inside structure (d) Construction of fourth-story

Photo 12 4-story apartment for employees of Oita Works in Akeno, Oita (1-hour fire-resistant building)

Table 2 Public certification and consultation of "NS-Super-Frame™"



panies have obtained the rating in December 2003 and, even thereafter, have continued to execute periodical updating, incorporating new technical findings and the results of the development made to comply with the needs of improvements delivered from users. Furthermore, concerning the "three-storied construction," the two companies obtained the authorization of the Article 1-3 of the Construction Regulation (hereafter called as authorization of Article 1-3) in July 2008, and updated in February 2015. Therefore, omission of the examination for judgement of the structural adaptability is permitted. Presently, the application for authorization of Article 1-3 for the "two-storied construction" has been submitted to the Ministry of Land, Infrastructure, Transport and Tourism, which is expected to be obtained at the end of 2015. As to the newly developed "four-storied construction," the structural system and the design standards were updated upon incorporation of high strength member materials and the rating was obtained in July 2014. As for the four-storied construction, it is the first construction system of this kind, which has been evaluated by a performance evaluating organization designated by our country.

Further to the above, in July 2015, the two companies obtained the rating of the designing to utilize the bearing wall developed for the four-storied construction that enables the construction of "one-story store buildings" having a large space with a sectional area of up to 1 000 m^2 with the wall height of 4.5 m, which can satisfy various scales of buildings and purposes of use.

4.4.2 Fire-resistance-related matter

The principal structural parts of constructions that have fireproof and fire-resistant performance have to secure non-damage characteristics, heat insulation properties, and flame shielding performance against an inside fire or an outside fire for a prescribed period of time. For the principal structural parts like exterior wall made of light-gauge shaped steel, parting wall, boundary wall, and boundary floor, illustrative specifications of notification like those provided for steel-framed structures and reinforced concrete structures are not arranged. Therefore, a fire-resistance performance test is conducted by a designated performance evaluating organization and only the specification that could satisfy the prescribed performance can be endowed with the fire-resistance authorization of the Minister of Land, Infrastructure, Transportation and Tourism. For example, in case of the external wall of 1-h fire resistance, a 3-h continuous loading test after 1-h loading and heating must be applied and needs to be observed to satisfactorily pass the inspection standards. The wall panel and the floor panel used in the NSSF construction system are the optimized structural member materials that fully conform to the abovementioned fire-resistance performance standards, realized by optimizing the material, thickness, lamination construction, fixing method, and so on of the membranes such as structural facing board, external wall, and gypsum board.

Presently, as for the principal structural parts of the "four-storied construction," the two companies have obtained the ministerial authorization of the 1-h fire-resistant structure. Furthermore, as to the principal structural parts of the "construction of three-storied or below," the ministerial authorization of the 1-h fire-resistant structure and the 60-min quasi-fire-resistant structure has been obtained.

4.4.3 Sound-insulation-related matter

From the viewpoint of securing privacy and comfortableness, securing sound shielding properties between the dwelling units inhabited by different dwellers is important. As for the "boundary wall" separating two dwelling units in a flat that are attached to each other, minimum required performance is specified by the Article 30 of the Building Standard Act and in the NSSF construction system, the authorization of the Minister of Land, Infrastructure, Transportation and Tourism conforming of the specification has been obtained.

Furthermore, for the public housing, a grade based on the "authorization based on the special evaluation method as per the law pertaining to the promotion of securing of quality of houses" (hereafter called special authorization) is demanded. Presently, as to the "boundary wall" of the "construction of three-storied or below," the two companies have applied to the Ministry of Land, Infrastructure, Transportation and Tourism for granting the special authorization of grade 2 of sound transmission loss (equivalent to the loss in wall thickness of 12 cm of reinforced concrete structure), which is expected to be issued within 2015. Henceforth, acquisition of the same special authorization for the "four-storied construction" is expected. Furthermore, as for the "boundary floor" between the upper dwelling unit and the lower dwelling unit, the special authorization for heavy floor impact noise countermeasures with dry double floor specification equivalent to that of a concrete slab of thickness 11 cm has been obtained.

4.4.4 Deterioration-countermeasures-related matter

Since the thickness of the light-gauge shaped steel is small and when the section is partially corroded, there is a danger of disappearance of structural strength. Therefore, the shaped steel is provided with rust-prevention treatment by surface finish. In the NSSF

construction system, high durability is realized by optimizing the thickness of the external thermal insulation material and the coating thickness of the high corrosion-resistant coated steel sheet "SuperDyma™" of Nippon Steel & Sumitomo Metal. Namely, two types of durability specifications have been developed. One is the "dew resistant type" in which the thickness of the exterior thermal insulation material is increased, intended not to allow dew condensation on the light-gauge shaped steel and another is the "rust preventive type" in which durability is maintained by the high corrosion-resistant coating although the thickness of the exterior thermal insulation material is made smaller, allowing the dew condensation on the shaped steel. The two companies have obtained the special authorization of both types, each conforming to the deterioration countermeasures grade 3 (service life 75–90 years).

5. Conclusion

The steel-framed house developed and standardized as KC type in 1997 by the industry has been evolved steadily by the NSSF construction system and has come to be recognized in the market.

The three-storied construction developed in 2004 has been incessantly employed to company dormitories and houses based on the high appreciation of short depreciable life (19 years) for the high durability (75–90 years) brought forth by the use of thin steel sheets of thickness below 3 mm in addition to the shortened construction period owing to the industrially manufactured panels. Furthermore, the homogeneous interior thermal environment and the comfortableness realized by the exterior thermal insulation and ventilation system was appreciated and applications of the NSSF construction system to group home-welfare facilities, special nursing home for aged people, children's facilities, and so on are growing practically. Furthermore, the applications of the NSSF construction system are spreading to large-scale objects in the field of store building owing to its attractions of the relationship between the short depreciable life and fixed-term land leasehold, possibility of early start of business, expanded effective sales floor space without any columnar structures, and so on.

With the joining of the four-storied construction newly, henceforth, it is expected that the NSSF construction system will be utilized widely in housing field, for public facilities, health and welfare facilities for aged people, and so on.

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