The Architecture of Earthquake Resistance

Julius Kahn’s Truscon Company and Frank Lloyd Wright’s Imperial Hotel

Frank Lloyd Wright considered the Imperial Hotel in Tokyo, designed and built from 1913 to 1923, to be among his most important works. It was his largest project built to that time, and after its survival in the great Kantō earthquake of 1923, it garnered international fame until its demolition in 1968 to make way for a much taller hotel structure on the site (Figure 1). Wright wrote at least eight essays on the Imperial Hotel, far more than on any other single building of his career. As Kathryn Smith noted in her definitive article on the project’s history, when asked to describe his accomplishments for *Who’s Who in America* in 1924, Wright replied: “The Imperial Hotel of Tokyo, Japan and 176 other Buildings of Note.” Histories of the Imperial Hotel discuss its unusual ornamental style, akin to that in Wright’s other buildings of the period. Yet Wright often said that the hotel’s importance in his work was that it demonstrated the efficacy of cantilevered steel-reinforced concrete as his preferred system of building. This method he distinguished from the steel frame, which he disliked (especially for tall buildings), and he envisioned all his later realized buildings and unbuilt projects for such structures in reinforced concrete as demonstrations of his theory of organic form. For Wright, the Imperial Hotel’s nearly undamaged survival in the most destructive quake ever recorded justified his preference. This event also shaped his thinking about modern architecture’s relationship to construction, which had been a central problem in his work since his apprenticeship in larger buildings with Adler and Sullivan in Chicago from 1887 to 1893.

Attendant to the question of the Imperial’s structural design are other puzzles about the building’s creation. Who were Wright’s collaborators and what was their role? What was the chronology of the design’s development in terms of structural decisions that affected its earthquake resistance? What was the context of Wright’s activity in Tokyo with respect to other architects and builders who were then also working on modern, seismically resilient structures? With these questions in mind, the Imperial’s story offers an excellent opportunity to study Wright’s relationship to the engineering profession and to his period’s building culture. While designing and realizing this structure, he was highly conscious of these issues, defining his position partly in response to them while choosing among his era’s contested theories and methods.

From this perspective, the Imperial Hotel’s structural design had its origins in the years after the San Francisco earthquake of 1906, which had prompted both extensive scientific study of seismic damage to buildings in the United States and debate among architects and engineers about the relative merits of the steel frame and reinforced concrete for earthquake resistance. In the latter field, the Trussed Concrete Steel or Truscon Steel Company, first of Detroit and later Youngstown, Ohio, founded by Julius Kahn—a younger brother of Albert Kahn—made an important contribution. In one account of the Imperial’s construction, Wright mentioned his use of the Kahn steel reinforcing bars, yet the Truscon Company’s Japanese branch claimed...
to have designed and supplied all the steel reinforcing for the hotel, thus playing a role that Wright did not clarify. Wright’s great hotel also represented his response to the tall steel-framed commercial buildings that the George A. Fuller Company built in Tokyo from 1920 to 1922. These were among the first structures of their kind in Japan, yet they were estimated to have suffered more severe damage in the great Kantō quake than the Imperial Hotel. Wright’s subsequent view of the Imperial became central to his idea of his own work and can be better understood as emerging from this culture of architectural engineering in its period.

Julius Kahn and the Truscon Company

In 1931, Wright professed that he “always had great respect” for the industrial architecture of Albert Kahn (1869–1942), including the Ford Motor Company factories in the Detroit area that Kahn himself had shown him. Yet for Wright’s architecture, perhaps the more important of the Kahn brothers was Julius (1874–1942). Albert partly financed Julius’s education in civil engineering at the University of Michigan. After graduating in 1896 and doing a series of apprenticeships in drafting and field work, Julius went to Japan in 1899–1900 to work for an engineering firm. One obituary noted that this “experience had a pronounced bearing on his later life. He studiously acquired a knowledge of the Japanese language.”

Upon returning to Detroit in 1901, Julius joined Albert as his chief engineer, concentrating on invention and manufacturing for concrete construction. Together with Albert’s mentor George B. Mason, the brothers built the University of Michigan’s Engineering Building at Ann Arbor (1902–4) using reinforced concrete.

Concerned about beams subject to bending and empirical systems of steel reinforcing then used to deal with such stresses, Julius, after making conclusive scientific tests, invented the “Kahn Trussed Bar.” As he explained in an arti-
Based on these two principles, the Kahn bar was a system of steel reinforcement including diagonal shear members rigidly attached to the main horizontal bar near a beam's bottom. Its aim was to prevent cracking in concrete beams associated with both shear and tensile bending stresses. The Kahn trussed bar was a patented steel reinforcing system that resisted stresses in concrete girders, lighter beams or joists, and floors. The original system consisted of a main horizontal bar along the beam's lower edge, where tensile stresses were greatest, with rigidly connected diagonal shear members extending up from the low horizontal bars (Figure 3). At first glance, it may appear that the Kahn bar's diagonal members were later joined to its lower horizontal bar. Yet, the whole Kahn bar was rolled as a single plate of steel, its sides scored to enable the upward bending of the diagonal members from the lower core. Though not clarified in Figure 3, these diagonals could vary in length to respond to variation in shear stress along the beam's length, with the longest diagonals set just to each side of the beam's center. As a single prefabricated steel system, fashioned as one rigid armature of metal and combining primary horizontal and secondary diagonal reinforcing, the Kahn trussed bar could be placed as a unit inside the wood formwork for pouring concrete beams. This design made concrete
reinforcement much more efficient to place, especially where skilled steel workers or rod setters were lacking. Their scientific design also made Kahn bars more reliable than the widespread practice of setting many small reinforcing bars individually inside concrete’s formwork.7

This invention was essential to the Kahn brothers’ famed later industrial architecture. To promote the “Kahn System” of construction, the Trussed Concrete Steel Company (renamed the Truscon Steel Company by 1921) was incorporated in October 1903. In 1914, Julius moved his Trussed Concrete Steel Company to Youngstown, Ohio, in order to be near sources of steel supply for manufacture of the Kahn bar or Kahn system of reinforced concrete, among his many related patents, including an early type of cantilevered floor slab (Figure 4).8

The San Francisco Earthquake and Reinforced Concrete Construction, 1906–1913

Truscon’s creation preceded the great earthquake and fire that destroyed much of San Francisco on 18 April 1906. This was the worst disaster of its kind in the history of the United States, and the city had been largely unprepared. Postquake fires could not be contained because the tremors had broken underground water mains. Need for analysis of damage prompted seismologists to study ground and building motion and to compare the resistance of different structural materials to earthquakes and fire.9 Experts concluded that when the earth’s surface moved in a quake, building damage due to vertical motion was minimal, whereas the destruction due to horizontal motion was considerable. As a Truscon vice president in Japan later noted:

The action of the horizontal movement in destroying or damaging buildings may be stated in non-technical words as follows: A violent and sudden horizontal movement occurs in the earth and is transmitted to the foundation of the building. . . . The inertia of the upper portion of the building tends to make it stay in its original position and the walls, columns and partitions are suddenly called upon for the strength necessary to overcome this inertia and move the building in the direction of the quake. Successive shocks follow, each moving the foundation horizontally forward and backward, the walls, columns and partitions having to perform the work of moving the part of the building that is above them with each horizontal movement of the earth.10

Another observer noted that when a tall Tokyo building moved laterally in the quake of 1923, it swayed “back and forth like an inverted pendulum” above the ground, with a natural period of elastic oscillation.11 The taller the building, the longer its natural period—in other words, the time it took for the whole building to complete one cycle of back-and-forth lateral movement (Figure 5). A longer natural period for a building more closely approximated the relatively long oscillatory periods of earthquakes. If the building resonated with the quake, then the seismic shocks would maximize architectural destruction. Also, different materials and structural parts swayed variably according to their individual natural periods of vibration. The differences among vibration periods of various materials exacerbated the differential internal or wracking stresses that tended to destroy the structure’s integrity.

To counter these stresses was the central concern of earthquake-resistant construction as it developed from the late nineteenth century. Yet through the 1920s, engineers had different ideas on how best to resist seismic shocks. After the San Francisco quake, one line of reasoning held that “the prime requisite for a structure to withstand earthquake shock is elasticity; that is, the ability to return without serious damage to its original shape and position after being distorted. It

Figure 4 Main plant of Truscon Steel Company, Youngstown, Ohio, 1914
should vibrate without offering great resistance to distortion; in other words, it should yield readily.” In this view, the stress produced by an earthquake in a structure is directly proportional to its rigidity; the stiffer the structure, the greater the stress. Hence “the more a structure is capable of yielding, like a willow tree to the storm, the less will be the tendency for earthquake rupture or collapse.” Yet other experts held that damage would be minimal if a structure was as rigid as possible against shock. In 1911, one American engineer wrote in a Trussed Concrete Steel Company booklet on earthquake design: “If all parts can be so firmly joined together that the building moves essentially as a unit, it may be said to be earthquake-proof.” To achieve this quality of rigidity, “the frame should be strong and well tied together, to obtain as nearly as possible the ‘monolithic’ condition, so that the building will vibrate as a unit.”

Engineers differed not only in their theories of optimal earthquake-resistant building but also in their views of which modern structural materials worked best. Analysis of San Francisco’s buildings after the quake led to the consensus that there were two types of viable earthquake-resistant construction, both of which insured as rigid a mass as possible. One method was the heavily braced steel frame; the other was monolithic steel-reinforced concrete. In terms of earthquake resistance, well-braced steel cages encased in stone and brick generally survived well because, it was reasoned, their frames vibrated as a whole structural unit. Yet brittle fireproof cladding of terra-cotta proved likely to crack and dislodge from steel skeletons leaving them exposed to fire, which did cause considerable damage to these steel-framed buildings, even if they did not collapse.

The only reinforced-concrete building of considerable size at the time of the quake was the six-story Bekins Van and Storage Company, at 190 West Mission Street, designed by Ralph Warner Hart and engineered by the Trussed Concrete Steel Company using the Kahn bar system. Its construction had gone only into the third story when the quake struck, yet this partial building had survived well (Figure 6). Soon reinforced concrete gained favor because it combined structural continuity and fire resistance—the two most essential qualities—in one constructive system. Fourteen months later, seventy-eight reinforced-concrete structures were being built in San Francisco, whose building codes were revised to permit reinforced concrete’s structural use. The survival of Kahn buildings in subsequent earthquakes elsewhere confirmed that...
reinforcing steel’s tensile strength gave reinforced concrete great coherence and high elasticity, making it ideal for earthquake resistance.17

In 1913, after returning from his first trip to Japan in connection with the Imperial Hotel, Wright proposed a twenty-five-story skyscraper, the *San Francisco Call Building*, for the southeast corner of the city’s axial Market Street at Fourth Street (Figure 7).18 He made this design for the headquarters of the newspaper, owned by John D. Spreckels, at the request of the Los Angeles architect Harrison Albright, for whom Wright’s son John Lloyd had been working since at least March 1912. Wright visited his son in Los Angeles in May 1913 after his return from Japan. Albright then was a major regional designer of fire-resistant reinforced-concrete commercial buildings.19 Wright labeled his *Call* Building project as a “Design for a Reinforced Concrete Skyscraper; Slab Construction,” noting on the plans that the building’s rear or south end wall would be a “concrete slab reinforced vertically”; apparently the north or front end wall would have been the same. Together with the floor slabs, the end walls would have braced the building against lateral wind and earthquake loads. The closely spaced vertical piers all around the exterior, if they were continuous reinforced columns, would have increased rigidity against lateral loads. As a concrete monolith, Wright’s *Call* Building would have been structurally fire resistant, in contrast to the steel-framed, 310-foot-tall Spreckels Building (1895–98), built as San Francisco’s tallest tower one block to the east on the southwest corner of Market at Third Street (Figure 8). Figure 7 shows that Wright’s tower was to link to the Spreckels Building via a new eleven-story mid-block structure. The Spreckels Buildings had survived
the 1906 earthquake, but the interior had been badly damaged in the ensuing fire and had to be partly rebuilt. The Call project's crowning cantilevered slabs would have succeeded the old Spreckels Building's capping dome atop San Francisco's skyline. As an imagined concrete critique of the steel frame for earthquake and fire, Wright's Call skyscraper project anticipated his monolithic Imperial Hotel and its later oppositional relationship to Tokyo's steel-framed buildings.

Wright's Accounts of the Structural Design for the Imperial Hotel

Evolving knowledge of earthquake-resistant construction after the San Francisco earthquake of 1906 influenced subsequent construction in Japan, where the science of seismology and related architectural engineering had developed from the Meiji era. From 1913 to 1922, Wright designed and built the Imperial Hotel—whose construction was the most complex he had ever undertaken—partly in response to this science. The new hotel was a private venture headed by the Imperial Household, which had been the largest stockholder in the old Imperial Hotel (1888–90). The discerning patron behind the project was the first Imperial's manager from 1909, Asakawa Hayashi, who had first contacted Wright in late 1911. The projected cost was two million dollars for the structure itself, plus a large sum for its equipment and furnishings. The ultimate cost was at least three million dollars, or about six million yen. With nearly three hundred rooms, the hotel was purposely not large in order to insure high standards of service to guests, but with its banquet hall to seat one thousand and theater to seat twelve hundred, its grand dining room opening onto garden courts, its private dining rooms, exhibition galleries, clubrooms, billiard rooms, and lounges, the building was “not only a mere hotel, but, what is even more important in many ways, a most complete and elaborate social center for foreign and test the soil’s bearing capacity. There is some indication that he made sketches for the hotel’s design on this trip. After returning to Taliesin, Wright made preliminary plans that were announced in Japan by December 1915. In March 1916, while Hayashi was visiting the United States, Wright contracted with the hotel to be its architect. Wright made his second trip to Japan for the project from December 1916 to April 1917, drawings in hand, and another set of plans were made in Tokyo by April’s end. It is thought that Wright and his assistants then created working drawings at Taliesin from May 1917 to May 1918. Demand for a new hotel grew during World War I, when Japan prospered and foreign visitors increased, and Wright’s structure was realized in a building boom after the war’s end in November 1918. Amidst armistice celebrations, Wright returned to Tokyo with his assistants to start building, though site clearance began only in May 1919 and construction that fall. It took nearly four years to completely finish the hotel for its projected official opening on 1 September 1923, the date of the great Kanto quake, though parts were in use from July 1922.

In addition to a number of architectural assistants both at Taliesin and in Tokyo, Wright worked with several technical specialists. His early structural engineer for the Imperial was Chicago based Julius Floto, who at first designed the reinforcing in accord with Chicago’s city building code. Also assisting with lighting, heating, and mechanical equipment was H. F. Durr of Chicago, who, at Wright’s request, sent his colleague Harry F. Mills to Tokyo to superintend installation. One later account noted that the hotel’s mechanical engineer was Samuel A. Lewis of Chicago. Paul Mueller, whose importance Wright noted, supervised the construction. One report claimed that Wright, Mueller, and Mills were the only foreigners connected with the building on site as it neared completion. In June 1919, Mueller and his son Ralph had departed Chicago for Japan to work on the hotel, with Ralph remaining there until November 1920. Once building was underway in 1919, Wright himself made three more extended trips to Japan between December 1919 and his final return home in July 1922.

Sited on a plot of about 3.5 acres along a major street southeast of Hibiya Park, itself edged by moats surrounding the Imperial Palace, the new hotel’s area including its enclosed garden courts was 300 by 500 feet (150,000 square feet). For the structural system, Wright apparently never hesitated to work with steel-reinforced concrete rather than the steel frame. In an undated statement, he specified that the building was to have “No fabricated Steel,” meaning no rolled steel columns and beams as its structural frame (Figure 9). Reinforced concrete would be logical for its earthquake and fire resistance in a building that spread over a large area as mostly three stories, except for the rear central pavilion atop the main public rooms, which rose to a height
equal to seven stories. This made the Imperial among the tallest modern buildings then rising in Tokyo, most of which were built with steel frames.

In discussing the Imperial Hotel's earthquake resistance, Wright in different contexts described the building as a monolithic construction of reinforced concrete, yet one whose technical details gave it a 'flexible' elasticity. To limit the transfer of lateral earthquake stresses from one part of the building to another and to accommodate thermal expansion and contraction of the concrete, he divided the building’s north and south wings into sections of about 40 feet each, as the intervals between projecting squared balconies (Figure 10). As he wrote to Louis Sullivan after the great Kantō quake, among the principles on which the Imperial was built was its 'monolithic construction divided at proper intervals clear through the building—(the Imperial is thus vertically cut into about twelve sections).’ Such seismic joints had long been recommended to structurally separate the parts of buildings planned with wings.

The most controversial aspect of Wright's structural design was the hotel's foundations, which he described as giving the building flexibility in response to lateral seismic shocks. The site had roughly 8 feet of alluvial soil above 60 feet of liquid mud, continuously saturated because it was below sea level, then hardpan or compact clay. Some architects and engineers in Tokyo believed that piles should be deep enough to connect with the hardpan, whose rigidity would help ensure the building's stability. Yet Wright was among those who believed that the optimal technique for resisting earthquake damage was the floating foundation on...
short concrete piles; he theorized that the building then would ride with the lateral seismic shocks like a ship floating on waves along the water’s surface, instead of resting on deep piles transferring lateral ground motion to the building and damaging it. He wrote, “because of the wave movements, deep foundations like long piles would oscillate and rock the structure. Therefore the foundation should be short or shallow.” Wright made tests by loading sample piles and measuring their settlement after frequent temblors. From these readings he decided on the diameters and lengths of the piles. As the Truscon Company later described the hotel:

The consideration of any building from an earthquake standpoint starts from the foundation. . . . The designer knew he
must penetrate below the unstable upper soil, yet he felt that, providing he could hold his building firmly together at the base and reduce the force which would be developed by the acceleration of the earth tremors acting on the mass of the building above, seismic damage would not and could not be serious. To accomplish this, reinforced concrete piles were placed at two foot centers to support the footings.39

Thus, the Imperial’s construction began with slightly tapering 8-inch wood piles driven into the soft ground 2 feet on center and then withdrawn, permanent concrete then quickly being poured into the cavities. Plans for the foundation show dense piling under peripheral walls all around the building, with squared clusters of piles under the piers (Figure 11). Continuous concrete slabs atop and joined to

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Figure 11 Wright, Imperial Hotel, foundation plan, showing pilings under walls and piers
the piles bound the foundation areas into rigid plates that would move laterally as a unit in a quake. Wright specified that soil and piles together be a “Foundation-Cushion; Soil reinforced to depth sufficient to take loads safely by casting into its texture small needles of concrete.”

In postquake fires, the greatest danger to any building was flames spreading to it from adjacent buildings. Thus, the hotel, while internally a monolith of reinforced concrete above ground, had almost wholly fireproof surfaces of tan brick and light green oya stone. Copper roofs referred to those of older temples in Shiba Park, south of the Imperial near the Tokyo waterfront, and as Wright noted, copper roofs were much lighter than traditional heavy tile roofs, lowering the building’s center of gravity and preventing damage from falling tiles in a quake. Yet, as Frederick Gutheim later wrote, beneath these surfaces “from a structural point of view this is in actuality a poured concrete building.” The most critical aspect above ground would be the steel reinforcing rods within the poured concrete slabs, the beams upholding those slabs, and the internal columns supporting the beams. Reinforced floor slabs were anchored to thick outer walls made of concrete between outer shells of brick and inner ones of hollow tile (Figure 12). One account noted that “an outer wall of brick was erected, and an inner wall of hollow tile. Between them were placed the steel reinforcing rods and the concrete was poured by hand. The building is a unit structurally as well as architecturally, the whole being a brocade of stone and brick and copper, through which run the threads of steel.”

These outer walls were sloped to keep their center of gravity low to enhance lateral stability. The steel reinforcing created both structural unity and elasticity in a quake. As Wright wrote: “why not extreme lightness combined with tenuity and flexibility instead of the great weight necessary to the greatest possible rigidity? Why not, then, a building made as the two hands thrust together palms inward, fingers interlocking and yielding to movement—but resilient to return to original position when distortion ceased.”

In terms of the reinforcing design, the key junctures would be, as in any structure, the transitions between the vertical columns and horizontal beams. As Wright wrote to Sullivan, the Imperial had “through transverse reinforcing in all lateral members—hooking into or onto the vertical reinforcement.” This internal steel reinforcing was the origin of the external architectural theme of the cantilever. As Sullivan wrote of the hotel: “slabs are as tenaciously yet flexibly adjusted to the vertical supports, and where occasion requires, the slab system merges from the concept of lintel into that of cantilever. There is here so general a use of the latter method, on account of its adaptability to projecting horizontal slabs otherwise unsupported and the resulting ease of creating unobstructed areas, that it may perhaps be described as in essence a reinforced-cantilever-slab-system.” Wright visually accentuated his cantilevers by freeing them at their outer edges so that their structural logic as unsupported overhangs was apparent (Figure 13). The result was a fireproof, flexible monolith suited to resist earthquakes and a cantilevered composition styled to convey the architecture’s essential structure. Yet the route to the final design involved important changes in the structural system, changes to which Wright alluded and in which Truscon later claimed a major role.

The Truscon Company’s Role in the Imperial Hotel

In his accounts of the Imperial Hotel, Wright hinted at the role of the Truscon Company in his great building’s realization, though records of their direct interaction are
In 1910 the Trussed Concrete Steel Company had sent its first representative to Japan, meaning that Julius Kahn was among the initial American entrepreneurs in the building industry who established themselves in that country. Soon after World War I ended, Kahn created a subsidiary, the Truscon Steel Company of Japan, with offices in Osaka, Nagoya, Fukuoka, a main office in Tokyo that had an engineering department, and a factory in Kawasaki for manufacture of the Kahn bar and other steel building materials. Most high-grade steel for fabrication was shipped from America. The Truscon factory, itself of fireproof steel-and-concrete construction, was on the south shore of Tokyo Bay about thirteen miles from the capital, between there and Yokohama (Figures 14, 15). This operation succeeded and by the time of the great Kantô quake in 1923, there were over 160 Truscon buildings in the devastated area around Tokyo and Yokohama, among the over 500 such buildings throughout the empire of Japan.

According to Julius Floto, who was based in Chicago and is not known to have gone to Japan, he at first had designed all the reinforced-concrete girders, beams, floors slabs and posts “in accord with the standard of the building code of the city of Chicago.” But “this gave rather heavier members than Mr. Wright thought necessary and he continually chafed under what he called the ‘excessive legal requirements’ and the ‘factor of safety,’ often using for the latter the time worn pleasantry of ‘factor of ignorance.’” Writing in 1924, after the hotel was built and had survived the great Kantô quake, Floto reported that Wright “tells me now that, in building, my computations were disregarded and that much lighter sections were everywhere substituted, making in effect a design which eliminated all the strength usually provided for the live loads.” In retrospect, Floto thought this was reasonable given that the building as a hotel would not likely have had to sustain the considerable live loads associated with the types of reinforced-concrete buildings, such as warehouses, for which the Chicago code had then been written.

Wright similarly recalled initially designing the hotel’s structure when he and his assistants likely made the working drawings between May 1917 and May 1918, when they were in the United States. In 1923, just after the construction had ended, Wright wrote:

In working out the concrete laterals, slabs and beams with my engineers at my workshop at Taliesin, I found the structure getting beyond control in weight. From the very beginning of this work, the size and weight of the members, forced by the accepted standards and “legal factors of safety” were a threat to the stability of the structure in violent movement, instead of safe assurance as intended. It was then I brought the cantilever principle into service. It had always appealed to me as a scientific means with new architectural possibilities, used purely as such, and also as working principle in the slab, continuous over supports, extended beyond the walls into balconies, canopies, cornices, etc. . . . But still the concrete in the laterals “to be
carried by itself” seemed to me excessive, and not until I got Mueller into action in our draughting room on the work itself did I get the results I wanted in lightening these dead loads.52

Further along in this same text, Wright used the phrase “upon the work” to mean on the building site in Tokyo. Wright’s office there was in his brick workshop near the hotel’s west front where he later placed its large pool. He and Mueller presumably conferred there after Mueller’s arrival in June 1919, just as the hotel’s site was being cleared.

Wright recalled that the major change in the structural design, “in the interest of lightening the construction, was from the flush slab I had worked out to a joist and girder system following the same general principles,” likely meaning the use of the cantilever.53

Wright here referred to the difference between a smooth planar deep floor slab of reinforced concrete, whose two-way structural strength is wholly contained within the slab’s depth, and a lighter, thinner reinforced-concrete floor slab supported underneath by reinforced-concrete beams and deeper girders that provide the main structural support for the slab. As we shall see, he preferred the architectural effect of the first method (planar slab), but later changed the design in the hotel’s wings to beams and girders upholding lighter slabs. Since at that time the quality of Japanese steel was too unreliable, the reinforcing had to be imported from the United States, just as the Truscon Company of Japan imported high-grade steel from America for fabrication into Kahn bars in its Kawasaki plant. Yet, Wright noted: “I had fallen down on the steel deliveries I had contracted for in America and found that the American Trad-

ing Company had a large stock of Kahn bars in Tokio. The lightening of the roof slabs by the use of this system appealed to me, but the furring of the ceiling entailed did not. But I consented to the redesigning of the floors on this basis, expecting to save greatly in weight and cost.” He wrote that the resulting need to make smooth plaster ceilings below such beamed slabs ultimately did not save much in weight or cost relative to a beautifully smooth finished planar slab.54

In April 1924, after the Kantô quake, the Truscon Company published a statement in Tokyo’s Japan Advertiser, as yet unremarked in the Wright literature, that described the company’s role in creating Wright’s Imperial Hotel (Figure 16). Truscon noted that over one million pounds of its reinforcing materials had been used in the building, and it reprinted a letter, likely of November 1919 (when Wright was in the United States), from Hayashi to Truscon confirming its terms for supplying the steel for the hotel. The firm contracted to supply “all reinforcing steel to be used for the Foundation, Piers, Columns, Slabs, Beams and Girders of all floors and all other places requiring reinforcing steel, as shown on the plans. We also agree to furnish plans showing the size, number and location of all bars.” Hayashi was pleased to note the saving effected by substituting the Kahn system of Reinforced Concrete based upon the foundation scheme worked out by Mr. Wright. We thank you most kindly for the part and interest you have taken in this matter. We sincerely trust and hope that the other reinforced concrete portions which you propose to redesign shall meet the same success and economy.
Figure 16 Advertisement, Truscon Steel Co. of Japan, Japan Advertiser, 13 Apr. 1924
But the redesigning should be done as ordered and approved by our architect, Mr. Frank Lloyd Wright.\textsuperscript{55}

This proposal was consistent with the Truscon Company’s practices worldwide. In this period the firm maintained its own large engineering department, with branches in all principal cities. The company thus provided not only reinforcing materials but structural design. In 1913, Truscon described that, for any building in which the Kahn system was used,

complete detailed drawings and designs of the reinforced concrete are prepared. These drawings show clearly the exact location of each reinforcing bar and the detailed size of all the concrete work. Each bar, when it leaves the factory, is given a distinctive mark which corresponds with its marking on the drawing. Each bar is designed for a distinct place in the structure, and the builder can tell at a glance where it belongs. The plans are prepared without cost for any structure in which the Kahn System is used. We co-operate to the fullest extent with all Architects, Engineers and Contractors.\textsuperscript{56}

Rudolf Schindler, who had headed Wright’s office in Los Angeles while Wright was often away in Japan, likely with Mueller’s participation after his arrival in June 1919. Such drawings would have been needed by the building season of 1920, since by July of that year, as Antonin Raymond explained, “I made a concession at that time in [lightening dead loads], which is a source of regret, in abandoning the flush slab for coffered construction.”\textsuperscript{59} The north wing plan shows such a beam-supported floor slab.

Figure 18 shows the detailed section of one such Beam A, seen in the top center of the beam schedule drawing (see Figure 17). The beam spans from the north corridor wall (right) to the north outside wall (left), where it frames into another larger concrete girder that runs the length of the outside wall. Spanning about 30 feet, Beam A contains a system of shear reinforcing with diagonal rods extending up from a lower tension rod along the beam’s bottom, just like the patented Kahn reinforcing bar (see Figure 3), rather than a system of shear reinforcing using a set of vertical U-shaped stirrups. As the Truscon Company described the hotel:

The floors above [the foundation] are adaptations of the cantilever principal [sic], all being sloped upward to the supported member. Kahn Trussed Bars were used throughout because of their rigidly connected shear members and because of their economy in this type of construction. . . . Thus vast numbers of hooks and stirrups were eliminated which would otherwise have been necessary to develop the needed bond between the concrete and the steel. The floors above are adaptations of one-way and two-way reinforced concrete slab construction, supported by reinforced concrete columns and walls.\textsuperscript{60}

Floto wrote of lighter, less costly members in the final structure, and the Truscon Company similarly described their work on the Imperial Hotel: “All the slabs are thin. Beams were sparingly used and in most cases were shallow and wide.”\textsuperscript{76} The structural system is schematically shown in the sectional diagrams that Wright published in later accounts of the Imperial Hotel (see A in Figure 12). Unlike the working drawing, the second-floor concrete slab is shown here
Figure 17 Wright, Imperial Hotel, beam schedule drawing showing northwest wing, with "A" showing Kahn-bar type reinforcing in cross section of Beam A supporting second-floor slab; graphic addition by Siry

Figure 18 Detail of Figure 17, showing cross section of Beam A with Kahn-bar type reinforcing supporting second-floor slab (as shown in Figure 3)
without either its internal reinforcing or its undergirding beam. This seamless slab is what Wright had ideally wanted; maybe it was realized elsewhere in the building, but he said it was not built as such in the wings. The smooth slab spans over the central corridor supports and anchors into the outer walls of brick-encased concrete. The second-floor cantilevers that Figure 12 shows extending freely beyond the outer walls occurred in reality only at the balconies. As Floto later described, Wright had created a monolithic concrete building inside and out. Yet, for the Imperial Hotel, the Kahn system was likely helpful because, since the shear and tension reinforcing bars were prefabricated units, they did not require as high a level of on-site skill from the Japanese craftsmen in their setting, as would have been the case if each bar of steel reinforcing had to be placed individually in the formwork. This saving was especially valued as the project went far past its projected completion time and over budget, partly opening in July 1922, soon after Wright had left Japan for the last time.62

In the midst of many factors that slowed building, the Kahn system enabled the hotel’s partial completion before and aided its survival in the earthquake of 26 April 1922, the most severe recorded in Japan in fifty-two years and which Wright experienced while still on the site.63 Overall, the Imperial’s construction corresponded to recommendations for earthquake-resistant design later discussed by R. F. Moss, vice president of the Truscon Company of Japan. First “with regard to foundations, the available evidence indicates that buildings on strong pile foundations receive more shock than buildings on the so-called mat or floating foundations.” As Wright had maintained, so Moss argued that “all parts of the foundation should be so well connected together that all will move as a unit.” He argued that since vertical members (walls and columns) had to move all the materials above them laterally in a quake, “it follows that in designing buildings to resist earthquakes, the floors should be made just as light as possible.” Moss stressed the importance of walls relative to columns, observing that in Tokyo, “The extent of the damage depended inversely on the strength of the walls. The principle [of] light floors and strong walls is by far the most important consideration in the design of buildings to resist earthquakes. The whole question of proper design rests on this principle.” Finally, as Wright stressed the integral nature of the Imperial’s reinforced concrete, so Moss wrote that “the attachment between the floors and the walls must be strong enough to enable the latter to move the former when the earthquake comes.”64 The similarity of Wright’s and Moss’s accounts supports Wright’s hint that he had developed the Imperial’s structure in collaboration with Truscon. Yet its design was one of several methods of earthquake-resistant building in Tokyo, where, as in San Francisco after 1906, reinforced concrete competed with the steel frame as the modern system of choice.

The George A. Fuller Company’s Buildings in Tokyo, 1919–1922

The Imperial Hotel is the best known work of an American architect in the Tokyo of the Taisho era, after the death of the Meiji emperor in 1912. Yet Wright’s project was created when the new American presence in the Japanese capital’s building industry was the George A. Fuller Company, which set the modern standard for steel construction in Tokyo and provided the context to which Wright contrasted his approach at the Imperial. Wright, his associates, and the hotel’s board and investors were most conscious of this comparison with their project. In spring 1920, Fuller’s heads, Paul and William Starrett, and Japanese leaders incorporated the George A. Fuller Company of the Orient Ltd. to build three big office buildings in Tokyo: one for Nippon Yusen Kaisha (Mail Steamship) Company, another for the Nippon Yaraku (Oil) Company, and a third, the Marunouchi Building. They were among the first large office buildings in Japan, and they introduced new methods of steel-framed construction, using heavy machinery such as pile drivers, dredges, and derricks from the United States. The aim was to instruct Japanese architects, engineers, and builders in these methods. All three projects were about one hundred feet high, the legal limit in Japan for the height of steel or concrete structures in business districts. Though all were designed by Japanese architects, Fuller’s Tokyo buildings were structurally engineered by H. V. Spurr, chief engineer for the renowned New York firm of Purdy and Henderson, working with Japanese engineers. All structural steel work was designed, fabricated, and shipped from the United States.65

The Fuller buildings in Tokyo differed slightly from each other, but they shared major characteristics. The local architectural firm of Sone and Chūjō designed the Nippon Mail Steamship Company and Nippon Oil Company buildings. The first was a seven-story office building (290 by 160 feet; 312,000 square feet; cost: 3,550,000 dollars; built November 1920 to December 1922), sited in front of the Tokyo Central Railway Station, with concrete caps atop deep wood-pile foundations below a steel frame clad in architectural terra-cotta and a granite base. The second, also a seven-story structure, was likewise in the Marunouchi district between the Imperial Palace and the station. It was smaller (165 by 160 feet; 200,000 square feet; cost:
2,200,000 dollars; built October 1920 to August 1922), and its steel frame was clad in tsukide or cut limestone for the first two stories and in terra-cotta above. Most materials were imported from the United States. These buildings had classically styled exteriors like the Flatiron Building in New York City, designed by Daniel H. Burnham and Company of Chicago and built by Fuller in 1902–3 as their most famous tower.66

Of Tokyo’s sixteen steel-frame buildings completed or in construction at the time of the great Kantō earthquake in 1923, the largest was the eight-story Marunouchi Building, sited opposite Tokyo’s central station, about five blocks north of Wright’s Imperial Hotel. The Marunouchi, also known as the Marubiru, built November 1920 to December 1922, was an investment for the Mitsubishi Corporation’s real estate division designed by architect Dr. Kotarō Sakurai (Figure 19). This block’s size of 335 by 275 feet (632,000 square feet) and cost (5,000,000 dollars) made it then East Asia’s largest structure and most expensive modern office building, housing about three hundred offices. Its structure was a steel frame, yet exteriors at the first story were of a heavy brick faced with granite and cast stone, above which were walls of brick and reinforced concrete faced with a local buff-colored tile. A crowning eighth story was of ornamental cast stone, set below the cornice of ornamental concrete. Inside were reinforced-concrete floors and wall partitions of solid brick, hollow brick reinforced with steel, reinforced concrete, and other materials to create a fully fireproof building. The Fuller Company had its own patented system of concrete reinforcing, which was used in its Tokyo buildings.67

Unlike the Imperial Hotel, the Fuller buildings in Tokyo were designed to resist earthquakes with foundations set on deep piles. According to this line of thought, different from Wright’s, movement at the surface is much greater than at even ten feet below the surface, especially in filled ground or marshy districts such as in central Tokyo, which rests on a former lake bed. So a prime requisite for stability was a deep and firm foundation with shafts set down through the soft earth, based on the theory that the piles’ direct connection to the hard clay below would brace the building above against seismic shocks. The Fuller buildings were set on deep wood piles of Oregon fir extending down to a firm bearing layer of hardpan clay 50 or 60 feet below the surface. Foundations had horizontal reinforced-concrete struts extending between column footings to tie together the whole pile-supported substructure for stability in the face of an earthquake shock.68 Above ground, the Fuller buildings featured large amounts of knee bracing and riveting with heavy diagonal steel braces between vertical columns and horizontal beams to create a rigid frame (Figure 20). The heavy steel skeleton was crafted to make the whole edifice vibrate as a unit and thus suffer minimal damage, like a monolithic concrete building.69

To Wright, the Fuller buildings’ deep foundations and rigid steel frames represented a technically misguided
approach. Moreover, he thought that their style exemplified the alien, imported classicism that he sought to avoid in his Imperial Hotel. While still in Tokyo, he criticized the Marunouchi Building (then nearing completion in 1922) as "typical of the West, typical of the worst side of the West which is given over solely to sordid utilitarianism. It has been built strictly for business. Its straight lines and its pitiful attempts at ornamentations [sic] have outdistanced even the West in sheer ugliness and incongruity and cause the visitor to Japan to despair of this Empire's attempts to change its culture." By contrast, Wright's new Imperial Hotel, also about to open, "which is an attempt to embody in brick and stone the living soul of a living Japan in universal terms, is a garden of beauty." Wright brought this oppositional stance to his ongoing debate with Fuller after the Kantō quake.

The Great Kantō Earthquake and the Performance of Fuller Buildings and the Imperial Hotel

The great Kantō earthquake of 1 September 1923 produced tremors and fires with destructive effects that were the worst in recorded history. Virtually all of Tokyo was then built of wood, in part because of its flexibility in response to tremors. The seismic waves and ensuing fire caused over ninety thousand deaths in the city and ruined nearly 7 square miles, burning over 75 percent of Tokyo's 483,000 buildings. Ironically, the quake occurred on the day that the Imperial Hotel was scheduled to have its completion ceremony. Communications from Tokyo were initially impossible, but on 8 September Wright's assistant Endo wrote a glowing report of the hotel's postquake condition, proclaiming, "what a glory it is to see the Imperial standing amidst the ashes of the whole city. . . . So the Imperial has come through the test and she stands like the sun, glory to you lieber-meister." Endo reported minor damage due to the tremors in his detailed observations of major rooms throughout the building. Wright's by-then former assistant Raymond, who was still in Tokyo at the time of the quake, similarly recalled that the Imperial Hotel had withstood the quake rather well, and the damage which it suffered was not serious. The floor of the dining room buckled both lengthwise and crosswise and the high rear portion sunk enough to necessitate a later change in the rear entrances from an ascent to a descent. It was in great danger of being gutted by fire, but the energetic efforts of the staff, assisted by foreign guests, put out the fires in time, so no serious damage occurred.

Another American on the scene noted that, while many had predicted that the Imperial would fail in a major tremor, "this pile of stones, this wild dream of an American architect, had met the test and stood better than any other building of its size in Tokyo." Apart from the overturning of statues in the entry court and small cracks, he reported that "there was no real damage—not a window broken, not a roof tile missing—nor could any serious weakening of the vital structure be seen." Wright, then living in Los Angeles, received several wires about the Imperial Hotel's fate. The Truscon Company later reprinted a cable sent from Tokyo to the architect presumed to be in Chicago on 5 September that read in part: "IMPERIAL HOTEL SAFE," and "Mr. Wright's reply: 'I KNEW IT.'" On 8 September, Wright wired Sullivan: "Direct wire from Tokyo purposely secured by Harry Chandler Editor of the Los Angeles Times reports Imperial Hotel undamaged mentioning only six other buildings as standing in Tokio but damaged Yankee skyscrapers now only twisted skeletons with nothing on their bones." On 13 September there was sent to Wright the most famous of these messages, which he later reprinted in his autobiography: "Following wireless received from Tokio today. 'Hotel stands undamaged as monument of your genius hundreds of homeless provided by perfectly maintained service congratulations signed Okura Impeho.'"

Planning to bring word of his triumph back to Chicago, where he soon went, Wright wasted no time in Los Angeles where he then resided and where the Kantō quake was front-page news. In an interview with the Los Angeles Times on 17 September, the day after he had received the relayed message from Okura, Wright, in his first public response to the quake, said: "What saved the Imperial was the principle of flexibility, flexible foundations, flexible connections, flexible piping and wiring systems, flexible continuous slabs cantilevering over supports—passing clear through the outer walls to become balconies or projecting cornices." As if comparing his building to a ship at sea, Wright said: "The cantilever which looked both dangerous and absurd to the critics absolutely trimmed and balanced the structure in the undulations, upheavals and twists."

From then on, Wright's claims about the Imperial Hotel sought to heighten the contrast between his construction's performance in the quake and that of the Fuller Company's new tall steel-framed buildings. He evidently chose to believe the account of his assistant Endo, an eyewitness, who reported that these structures, such as the Marunouchi Building, had suffered considerable damage, with one "seriously destroyed showing the steel-work inside bent like iron tongs
all steel building fatal. . . . These are enough to show that our architects were fools and Fuller’s were ‘holy fools.’”

Wright based his own later comments on the Fuller buildings on this assessment. Yet Endo’s report about the Fuller buildings differed partly from other accounts of their performance: they did not collapse, but suffered more extensive damage than the Imperial. One American witness who lived to escape the flaming city recalled:

I could see Tokyo’s biggest buildings swaying like huge masses of jelly. Loosened brick and terra-cotta were falling to the street like leaves blown off a tree in Autumn. It was almost inconceivable to see and difficult to realize that such apparently massive buildings could behave in that manner. . . . The tops of the new [Marunouchi] building and the Nippon Yusen Kaisha office building were trying to bridge the distance across the narrow street as they swayed from side to side. But the remarkable fact remained that these buildings, as well as practically all the reinforced steel structures, did not fall or collapse.

He reported that the Marunouchi Building suffered only minor damage, and no one was killed. The Fuller Company’s treasurer cabled from Tokyo on 18 September: “All our buildings damaged to some extent, but not beyond repair, damages being chiefly to cracks in brick walls and terra-cotta on first and second floors of each building. Outside [terra-cotta] tiling on Marunouchi Building badly buckled, otherwise apparently all right. Steel frames intact.”

After the quake, there followed assessments made by seismologists and insurance companies that rated the relative damage to individual buildings. Fuller’s three steel-framed buildings “were seriously damaged,” though they did not collapse and were repaired. Figure 21 shows photographs of the Nippon Yusen Kaisha Company and Nippon Oil Company buildings taken for the Fuller Company twenty-seven days after the quake. Nippon Oil’s building was described as “damaged severely in general,” with much cracking of exterior walls, interior court walls, and interior partitions. The view shows the shear or X-cracks on the exterior that mark the wall’s in-plane failure due to lateral movement that broke bonds between outer terra-cotta pieces. Cost of repairs and internal restructuring were estimated at 40 to 50 percent of the building’s original cost of 2,200,000 dollars, though repairs had not yet been made at the time of the survey in mid-1926. By then, finished repairs of the Marunouchi Building’s damage, with “exterior walls cracked on all sides,” were assessed at 1,500,000 dollars, or 40 percent of its original cost of 3,700,000 dollars. Repairs to the Nippon Yusen Kaisha Building were figured at 900,000 dollars, or 25 to 30 percent of its cost of 2,380,000 dollars. Endo had written to Wright of the Fuller buildings’ steel frames twisted in the quake, and another report
concluded that their performance “shows that steel frame bracing can be buckled and sheared off and that steel columns may be badly distorted.”

By contrast, though actual cost of repairs to the Imperial Hotel is not known, reports other than Wright’s attested to its remarkable performance in the quake, and according to one account, damage was assessed at only 8 percent of the hotel’s cost of rebuilding if it had been leveled. While recent scholarship has questioned Wright’s claims that the Imperial suffered little structural damage relative to other modern buildings in Tokyo, the total available evidence indicates that the building did perform quite well, sustaining only minor damage. What Wright either did not know or did not acknowledge was that there were other modern structures of steel or reinforced concrete that performed as well or better. Yet, part of what distinguished the Imperial Hotel after the quake was not only that it performed well technically, but also, as the hotel’s then-new manager Tetsuzo Inumaru testified in detail, the building’s resilience enabled it to play an extraordinary and, in some respects, a unique role as a center for humanitarian relief in the aftermath of the quake. Inumaru reported that the hotel survived with the need for “only a few slight repairs.” As Wright wrote, “the building never went out of service during the quake.” Other than the hotel at Tokyo’s Central Railway Station, the Imperial among the city’s large hotels remained operable to care for guests and countless local refugees.

A view of the Imperial looking east from Hibiya Park before the quake (Figure 22) may be compared with a postquake view looking south that shows its rear seven-story mass with crowning hipped roofs towering like a fortress amidst its burned out district (Figure 23). As a Los Angeles editor wrote, the hotel’s survival was “a splendid tribute to the invincibility of science under the attacks of nature in her fiercest manifestations.” Hayashi, awarding the reinforcing contract in November 1919, had thanked the Truscon Company of Japan for its “support and interest for the sake of a monument that will stand the test of time.” His praise was then politely formulaic, but it turned out to be prophetic of the company’s contribution to the structure’s performance. Okura attributed the Imperial’s survival to Wright’s genius, yet the Truscon Company also deserves credit.

The Imperial Hotel’s survival was the reference point for Wright’s subsequent advocacy of cantilevered, reinforced-concrete construction for tall buildings. He saw the Imperial’s
success in the quake as a stunning vindication of his principle of organic architecture. Earlier, Sullivan had developed this idea to mean continuity of form, which Wright had seen Sullivan realize in his ornament and which Wright adapted as three-dimensional structural and spatial continuity. Sullivan published his first laudatory article on the Imperial in April 1923, a year after it had well survived the quake in April 1922 and five months before the great quake of September 1923. In June 1923, Wright wrote to his mentor of this article: “I am sure the effect of it will be good for us both and for THE CAUSE—to which we have both devoted our lives.”93 On 8 September 1923, upon receiving Endo’s cable confirming the Imperial’s survival, Wright wired Sullivan, stressing the contrast with Fuller’s buildings and closing: “Cheer up Lieber Meister. Our fortune is made.”94 On 26 September, in his last extant letter to Sullivan before Sullivan’s death in April 1924, Wright wrote:

The Yankee Skyscrapers are some of them standing, badly cracked and some with the top floors shaken down—all visibly seriously damaged probably murdering thousands trapped in them—unable to get out. . . . And this congestion on the basis of eight or ten stories where it was already far too great for safety or comfort on the basis of three stories—was a crime—but a tribute to Yankee salesmanship. I am opposed to the tall building from now on, in the Pacific basin.

Proposing that Sullivan help him publicize the Imperial Hotel’s survival, Wright stated: “this publicity I need and want, to strengthen my arm in the coming tussle with what Starrett stands for in toto and in Tokyo.”95 Writing from Los Angeles after the great quake but before returning to Tâllesin in October 1923, Wright rebutted William Starrett, who described the Fuller Company’s approach to modern building in Tokyo in an article of September in Scribner’s Monthly entitled “New Construction in an Ancient Empire.” Wright argued that “sooner or later all steel framing will perish, even where conditions are most favorable to its existence. In Tokio, conditions were naturally unfavorable. All steel perishes with fearful rapidity owing to extraordinary humidity and a salt-sea atmosphere.” Wright reasoned that “the perpetual wrenching or jolting of the semi-rigid frame weakens, cracks, or breaks off its concrete shell, thus exposing the steel to the flames which always accompany heavy tremors, and steel, exposed to flame, soon bends its riveted knees and comes to the ground.”96 To Wright, Fuller’s steel-framed structures were misguided aesthetically, their classicism being alien to Japan. By contrast, the Imperial Hotel’s technical integrity paralleled its aesthetic merit, intended as a tribute to Japan. Its survival validated Wright’s conviction that its structural principles of cantilevered concrete, more than the steel frame, pointed the way for modern architecture, not just in Japan but worldwide. The Truscon Company’s role at the Imperial Hotel thus helped to restore its fifty-six-year-old architect’s faith in structural ideas that he had pursued for decades and that would continue to animate his later life’s work.

Notes
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2. In its ornamental style, Wright’s Imperial Hotel has been grouped with these and visually similar unbuilt projects are often discussed as Mesopotamian in their inspiration, although Wright repeatedly described the Imperial Hotel as a modern tribute to old Japan, sympathetically related to

THE ARCHITECTURE OF EARTHQUAKE RESISTANCE


17. Estes, *Earthquake-Proof Construction*, 13–14, 29–34. Truscon buildings had performed well in earthquakes at Kingston, Jamaica (1907); Messina, Sicily (1908); Cartago and San José, Costa Rica (1910); and Manila, Philippines (1911).


20. Local architects James and Merritt Reid had designed the Sprechels
Building for John D.’s father, Klaus. Its structural engineer was Charles Louis Strobel of Chicago. See “A Marble Palace for ‘The Call’; A Marvel Building for John D.’s father, Klaus. Its structural engineer was Charles.

Earthquake and Fire

Apr. 1922 that damaged the old hotel and prompted his and most of the

to succeed his father as the board’s chair in June 1922.

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Acted in Japan Quake,”

pleted Imperial Hotel at $4,000,000; Stanley E. Stady, “How Buildings

Engineer

Imperial Hotel, Tokyo,”

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Louis Christian Mullgardt, “A Building That Is Wrong,”

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Wright noted Durr and Mills in “In the Cause of Architecture: In the Wake of the Quake—Con-

Japan Advertiser, 17 Aug. 1895, 1; “The Sprechels Building, San Francisco,” Engineering Record 37, no. 19 (9 Apr. 1898), 412–14; and no. 20 (16 Apr. 1898), 433–37; Gilbert et al., San Francisco Earthquake and Fire, 34–35; and Tobriner, Bracing for Disaster, 88–90, 102, 124, 126, 139, 141–43, 156–57, 158, 214, 216, 239.

21. The most eminent Japanese seismologist was Professor Fusakichi Omori. See Charles Davison, “Fusakichi Omori, and His Work on Earth-

22. The Imperial Royal Household owned about 30 percent of the stock in the original hotel. Wright later recalled that its share in the new building was 60 percent; Wright, Autobiography (1932), in Pfeiffer, Wright: Collected Writings, 2:263 (see n. 1). It was financially managed by a set of investors headed by Baron Kikuchi Okura, who had been instrumental in creating the first Imperial Hotel in 1890, and his son, Kishichiro, who was elected to succeed his father as the board’s chair in June 1922.

23. Hayashi was central to the new building’s creation up to the fire of 16 Apr. 1922 that damaged the old hotel and prompted his and most of the board’s resignations. On Okura and Hayashi, see Imperial Hotel, The Imperial: The First Hundred Years (Tokyo, 1990), 72–97; and Frank Lloyd Wright, “In the Cause of Architecture: In the Wake of the Quake—Concerning the Imperial Hotel, Tokyo, II,” Western Architect 33, no. 2 (Feb. 1924), in Pfeiffer, Wright: Collected Writings, 1:191–92 (see n. 1).

24. Louis Christian Mullgardt, “A Building That Is Wrong,” Architect and Engineer 71 (Nov. 1922), 81. Another account placed the cost of the completed Imperial Hotel at $4,000,000; Stanley E. Stady, “How Buildings Acted in Japan Quake,” American Contractor 44, no. 52 (29 Dec. 1923), 16. Another noted the company’s eventual total capitalization as 9,000,000 yen or about $4,100,000; Hessell Tiltman, The Imperial Hotel Story (Tokyo, 1970), 16. The estimate of $2,000,000 appeared in Western Architect 25, no. 1 (Jan. 1917), 4, which noted a banquet tendered Wright by his Chicago friends in Dec. 1916 before he left for Japan with his son John Lloyd.


26. This view of the hotel’s purpose recurs in Wright’s accounts, and press descriptions, such as “Soon to Begin New Imperial Hotel,” “New Imperial Hotel Will Be Completed in November 1921,” Japan Advertiser, America-Japan Number, 14 May 1920, 14.

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After Wright arrived in Nov. 1918 to begin construction, he had a brick workshop built on the hotel’s west front where the large pool was later made; Kirishiki, “Story of Imperial Hotel,” 134. Wright’s main assistant Endo “recruited our official ranks with some twenty young students from [the University of Tokyo] or from Kyoto or Waseda,” Wright, “In the Cause of Imperial Hotel,” in Pfeiffer, Wright: Collected Writings, 1:186. Kirishiki also listed the on-site assistants as Takahashi, Kawano, Ito, Tanoue, Uchiyama, and Fujiyama. Rudolf Schindler worked for Wright from Feb. 1918 to Aug. 1922. While Schindler did not go to Japan, he headed Wright’s American practice while Wright was in Japan and handled many details of acquiring materials and equipment for the Imperial Hotel. See Judith Shene, R. M. Schindler (London, 2001), 29–44.


32. The Imperial Hotel’s ground area was about 2.2 times that of Adler and Sullivan’s Chicago Auditorium Building (187 by 362 feet; ca. 68,000 square feet), which, at ten stories in height, had been Wright’s introduction to large hotel construction. See Sullivan, “Concerning the Imperial Hotel, Tokyo, Japan,” Architectural Record 33, no. 4 (Apr. 1923), in Twombly, Sullivan: Public Papers, 236–37 (see n. 1).

33. “Architects [sic] Specifications. Engineering Principles to Be Applied in Construction of Imperial Hotel, Tokyo, Japan,” FLWA, item no. 1028.025, fiche 5, row 1, frame 9, emphasis in original. Modern reinforced-concrete building had developed in Tokyo since about 1910, as noted in “Japanese Engineering Structures and Services,” Engineering News-Record 91 (13 Sept. 1923), 434. Though reinforced concrete had been used earlier for bridges and other structures designed by engineers, the first architect-designed reinforced-concrete building in Tokyo was the four-story Yokohama Mitsui Bussan Office Building (1911; additions, 1927), designed by Oto Endō and Yūnosuke Sakai. See Hiroshi Watanabe, The Architecture of Tokyo (London, 2001), 61, 77.

34. The Imperial Hotel’s salient height was noted in Frank Lloyd Wright to Louis Sullivan, 26 Sept. 1923, FLWA, fiche id. S010A03, in Frank Lloyd Wright: Letters to Architects, ed. Bruce Brooks Pfeiffer (Fresno, Calif., 1984), 39; “Imperial Hotel, Tokyo,” Japan Advertiser, 13 Apr. 1924, 3; and Sullivan, “Concerning the Imperial Hotel,” in Twombly, Sullivan: Public Papers, 236.

35. Apart from his tributes to Sullivan after his death in Apr. 1924, almost all Wright’s publications of 1922 through 1925 were on the Imperial Hotel, as listed in Levine, Architecture of Wright, 450–51 n. 2, and n. 1 above. Some key texts, cited in the notes to this article, appeared only in Tokyo’s main English-language newspaper, the Japan Advertiser.

36. Wright to Sullivan, 26 Sept. 1923, in Pfeiffer, Wright: Letters to Architects, 40. Later Wright recalled: “Now how to make the flexible structure instead of the rigid foolish one! Divide the building into parts,” Wright, Autobiography (1932), (see n. 2), in Pfeiffer, Wright: Collected Writings, 2: 261. Floto “Imperial Hotel,” 123, recalled that floor slabs and beams “all were designed according to the best engineering practice into monolithic units of about 60 foot length separated by expansion joints.” On the advisability of seismic joints between building wings, see Wakabayashi, Earthquake-Resistant Buildings, 225–26 (see n. 1).

37. Long fir piles were the preferred method for setting foundations in the tall steel-frame buildings of the George A. Fuller Co. in Tokyo, discussed below in n. 68. Floto, “Imperial Hotel,” 121, wrote that, unlike Wright’s floating foundation for the Imperial Hotel, long piles down to rock “transmitted the full intensity of shocks.” Wright ridiculed long piles for foundations of steel buildings in Tokyo, Wright, Experimenting with Human Lives (see n. 1), in Pfeiffer, Wright: Collected Writings, 1:171.

38. Wright, Autobiography (1932), in Pfeiffer, Wright: Collected Writings, 2:259. After the great Kantō quake, seismologists at Tokyo University had come to similar conclusions. They argued that for monolithic buildings on soft ground, “the rigidity of the buildings being far greater than that of the ground on which they stand, the buildings should behave like pebbles placed on gelatin, and there is the possibility that they actually rock as a whole upon the soft ground.” Koyo Suyehiro and Mishio Ishimoto, “On the Vibration of Low Monolithic Buildings,” National Research Council of Japan, Proceedings of the Third Pan Pacific Science Congress, Tokyo, 1926 (Tokyo, 1926), 2:1482. The great earthquake revealed that “those buildings on muddy earth having the foundation made in one slab [raft foundation] stood the shock better than those having comparatively strong foundations resting on deep piling.” Ibid., 2:1485. After testing vibrations of a low monolithic ferroconcrete building in Tokyo, these scientists concluded that “notwithstanding the irregular oscillations of the ground, the building oscillates in a regular manner, just like a ship rolling comparatively regularly with her own period on a choppy sea. . . . We may infer that rigid buildings make rocking motions on the ground as rigid bodies.” Hence “this possibility has an important bearing on the problem of earthquake-proof construction.” Ibid., 2:1485, 1486. David B. Stewart, The Making of a Modern Japanese Architecture: 1868 to the Present (New York, 1987), 43, noted that the German firm of Ecke and Böckmann had introduced floating foundations at Tokyo in 1895.

39. “Imperial Hotel, Tokyo,” Japan Advertiser, 13 Apr. 1924, 3. Foundations were initially discussed in “New Imperial Hotel,” Japan Advertiser, 12 Apr. 1922, 3. John Lloyd Wright, My Father Who Is on Earth, 97 (see n. 19), described the testing, which is documented in one drawing that shows boring tests of Jan. 1927 to determine the soil’s composition at different depths and locations on the site (FLWA, drawing no. 1509.615) and another that shows loading and settlement measurements from Feb. to Apr. 1917 for different types of concrete piles (FLWA, drawing no. 1509.616). Wright described such tests in “In the Cause of Architecture; In the Wake of the Quake,” in Pfeiffer, Wright: Collected Writings, 1:184; and Autobiography (1932), in Pfeiffer, Wright: Collected Writings, 2: 260–61. Some 324 pages of engineering diagrams, calculations, quantities surveys, etc., for the Imperial Hotel are in FLWA, item no. 1028.025. After the quake of Apr. 1922, but before the great Kantō quake, Wright wrote: “The scientific basis, tests, and figures upon which this foundation was put in will sometime be put on record by myself.” Frank Lloyd Wright, “Facts Regarding the Imperial Hotel,” in Pfeiffer, ed., Wright: Collected Writings, 1:205.


41. “New Imperial Hotel Is a Dream,” 3 (see n. 1). In Shiba Park were the burial shrines of seven Tokugawa Shoguns on the grounds of the Buddhist Zojoji Temple, relocated there in 1598; “Tombs of the Shoguns at Shiba,” Japan Advertiser, 17 Nov. 1921, 4. These shrines were destroyed in 1945; Watanabe, Architecture of Tokyo, 28. Wright, Autobiography (1932), in Pfeiffer,

43. “New Imperial Hotel Is a Dream,” 1. Also see Floto, “Imperial Hotel,” 121.


45. Wright to Sullivan, 26 Sept. 1923, in Pfeiffer, *Wright: Letters to Archi-

46. Sullivan, “Concerning the Imperial Hotel” (see n. 34), in Twombly, *Sulli-

47. Floto, “Imperial Hotel,” 123, noted that concrete cantilevers were not

48. In 1937, the Truscon Company was sold to Republic Steel, whose cor-

49. Irwin, “Julius Kahn,” 3 (see n. 3). By 1913, Truscon had “experience in

50. “American Engineers Aid Japan,” *Iron Trade Review* 73 (13 Sept. 1923),

51. Floto, “Imperial Hotel,” 122. Wright first wanted flat, beamless slabs.

52. Wright, “In the Cause of Architecture: In the Wake of the Quake, I” (see n. 28), in Pfeiffer, *Wright: Collected Writings*, 1:185. On p. 186 Wright added: “Finally, through Hayashi’s efforts I got permission to send for Paul F. P. Mueller, the Chicago builder, old comrade-in-arms, who unselfishly came and for more than four years scarcely a rod was laid or bucket of con-

53. Wright, “In the Cause of Architecture: In the Wake of the Quake, II” (see n. 23), in Pfeiffer, *Wright: Collected Writings*, 1:187. Wright specified: “Continuous flat slabs to be given preference to beam and slab construction wherever economically reasonable. Two way reinforcing to be used whenever conditions do not render it an economic absurdity.” “Architects Specifications.”


55. “Imperial Hotel,” *Japan Advertiser*, 13 Apr. 1924, 3. Hayashi’s letter responds to the Truscon Co. of Japan’s proposal dated 6 Nov. (1919), and its supplementary quotation on 7 Nov. Hayashi’s reply itself is undated.


57. Antonin Raymond to Frank Lloyd Wright, 20 July 1920, FLWA, fiche id. R001D05. The Wright Archives dates this letter to 20 July 1919; Raymond wrote the year as 1920.


59. Wright, “In the Cause of Architecture: In the Wake of the Quake, I,” in Pfeiffer, *Wright: Collected Writings*, 1:185. Years later Wright wrote of Schindler to his eldest son Lloyd: “I do not know to what he refers when he says: ‘structural features that held the Imperial together incorporated only after overcoming my resistance,’” Frank Lloyd Wright to Lloyd Wright, 19 June 1931, FLWA, fiche id. W056B01. Soon after he again wrote to Lloyd: “I suspect on thinking the matter over that Rudy must refer to the omission in the wings of the solid unplastered continuous slab I designed and wanted in favor of the beam-slab—and the Youngstown [i.e., Truscon] steel! That is the only thing I accepted reluctantly and wished afterward, and now, that I had not consented to do. That, I allowed in the wings only. The rest of the building was as I designed it. I consented to this to save costs but found the extra cost in the troublesome form of waste was terrific, and the weight of the expanded metal ceiling with the inch or inch and a half of solid plaster that piled up on it by Japanese plastering methods not only cut the saving down to practically nothing but introduced a perishable element into the building that I hated then and hate now to think of. I intended to splash the concrete surfaces of the ceilings with powdered shell a la Japan. It affected the principle of design otherwise not at all. Plenty of buildings with the beam slabs fell down. The expected saving in weight was almost wholly lost by the heavy added weight of a metal lathed and plastered ceil-

60. “Imperial Hotel,” *Japan Advertiser*, 13 Apr. 1924, 3.

61. Ibid.

62. On Wright’s departure, see *Autobiography* (1912; see n. 1), in Pfeiffer, *Wright: Collected Writings*, 2:264–65; and Imperial Hotel, *Imperial: First Hundred Years*, 114–16 (see n. 25).


64. Moss, “Earthquake-Resistant Construction,” 183–84 (see n. 10); emphasis in original. Also see E. M. Scofield, letter, 11 Jan. 1924, “Flexure of Buildings in Earthquakes,” *Engineering News-Record* 92, no. 8 (21 Feb. 1924), 336, who held that, for tall buildings, “columns and girders should be flexible with extra strong connections to develop this flexure.”


68. “Japanese Engineering Structures and Services,” 435–36. Piles were imported from the U.S. Pacific Coast, as local Japanese timber was too short to penetrate to hardpan.

69. According to James A. Baird, who succeeded Paul Starrett as the Fuller Company’s president after the Starrett brothers had left to form their own company in 1922, their Tokyo buildings had “steel skeletons of extra weight to resist earthquakes. They are powerfully wind and earthquake resistant. This means that extra [gusset] plates are used to join the steel beams onto the steel columns. This stiffens up the whole skeleton and caused it to move in one piece.” “Yank Buildings Survive Quake,” Los Angeles Times, 6 Sept. 1923, pt. I, 11.

70. Wright, paraphrased in “New Imperial Hotel Is a Dream,” 8 (see n. 41).

71. Wright had been invited to this event, but he had declined to travel again to Japan. See Masami Tanigawa, “Wright’s Achievement in Japan,” in Shinji Komoto and Jonathan Lipman, eds., Frank Lloyd Wright Retrospective (Tokyo, 1991), 58. Accounts of the great Kantō earthquake include Joseph Dahmann, The Great Tokio Earthquake, September 1, 1923: Experiences and Impressions of an Eye-Witness, trans. Victor F. Gettleman (New York, 1924); Charles Davison, The Japanese Earthquake of 1923 (London, 1931), 6–23, 42–51; Noel F. Busch, Two Minutes to Noon (London, 1962); Otis Manchester Poole, The Death of Old Yokohama in the Great Japanese Earthquake of September 1, 1923 (London, 1968); Charles D. James, Susan Fatemi, and Edgar Sykes, Aftershocks: Photographs of the 1906 San Francisco and 1923 Tokyo Earthquakes (Berkeley, 2002); and Joshua Hammer, Yokohama Burning: The Deadly 1923 Earthquake and Fire that Helped Forge the Path to World War II (New York, 2006). Professor Terry Smith of Brown University is currently writing a social and cultural history of the effects of the great Kantō earthquake. See also Akitume Inamura, “The Great Earthquake of S.E. Japan on Sept. 1, 1923, with Two Appendices,” in National Research Coun-
commissioned by a San Francisco brick company (possibly the Clay Products Institute of California) to do a complete film survey of the earthquake area in order to establish the comparative earthquake-resistant properties of brick, concrete, and ferroconcrete. Apart from Naito's nearly unharmed buildings, the least damaged large modern buildings in Tokyo were the reinforced concrete Mitsui Building (1919–20; 2–5 percent) and the steel-framed Kajio Building (1914–19; 8–10 percent; Tokyo Earthquake of 1923, 6, 8.

87. The Tokyo Building Inspection Department tabulated damage to various types of structures other than wood as a result of the earthquake and fire. Among five categories (entirely collapsed, half collapsed, heavily damaged, slightly damaged, and undamaged), this report noted that Tokyo's 651 reinforced-concrete buildings, 148 (23.5 percent) were assessed as undamaged, 221 (35 percent) as slightly damaged, and 248 (39.3 percent) as heavily damaged. Earthquake and Building Construction, 32, cited in Robert K. Reitherman, "Frank Lloyd Wright's Imperial Hotel: A Sesame Re-Evaluation," Structural Aspects, vol. 4 of Proceedings of the Seventh World Congress on Earthquake Engineering (Istanbul, 1980), pt. 1, 147. Also see Reitherman, "The Sesame Legend of the Imperial Hotel: How Did It Really Fare in the Tokyo Earthquake of 1923," American Institute of Architects Journal, 69, no. 7 (June 1980), 42–47, 70; and Richard M. Bennett, letter, "Imperial's Structures Institute of California) to do a complete film survey of the earthquake commission by a San Francisco brick company (possibly the Clay Prod-

88. Tetsuo Inamura, “The Imperial Hotel in an Emergency,” Japan Advertiser, 24 Jan. 1924, 1, rpt. from The Tourist (issued by the Japan Tourist Bureau), and rpt. in Tiltman, Imperial Hotel Story, 18-26 (see n. 24). With municipal water out, Wright's huge pool in the entry court was a key source of water to prevent neighboring fires from spreading to the building. Inamura reported that on 5 Sept. the hotel received the city's first revived electric power, since the Tokyo Electric Company's offices had relocated there along with those of other important public utilities and firms needed for reconstruction. Likewise the American, British, French, Italian, Swedish, and Chinese embassies were reestablished in Wright's hotel, in addition to hundreds of refugees who were housed and fed there. By afternoon on the day of the quake, thousands of refugees also found temporary shelter in the vast halls of Tokyo's Central Station, near Wright's hotel. Other major hotels were destroyed. See Dahmann, Great Tokyo Earthquake, 85 (see n. 71).

89. Wright, "In the Cause of Architecture; In the Wake of the Quake, II" (see n. 23), in Pfeiffer, Wright: Collected Writings, 1:189 (see n. 1).


92. “Imperial Hotel, Tokyo,” Japan Advertiser, 13 Apr. 1924, 3.

93. Frank Lloyd Wright to Louis Sullivan, 8 June 1923, FLWA, fiche id. S009E04, in Pfeiffer, Wright: Letters to Architects, 23 (see n. 34).

94. Wright to Sullivan, 8 Sept. 1928 (see n. 76), in Pfeiffer, ed., Wright: Letters to Architects, 38.

95. Wright to Sullivan, 26 Sept. 1923 (see n. 34), in Pfeiffer, Wright: Letters to Architects, 40. Sullivan wrote a supportive essay, “Reflections on the Tokyo Disaster” (see n. 1), his last to be published before his death.

96. Wright, Experimenting with Human Lives (see n. 1), in Pfeiffer, Wright: Collected Writings, 1:170. As stated in n. 1, a slightly different version of Wright's essay reappeared as "Why Perpetuate the Skyscraper?” Japan Advertiser, 9 Jan. 1924, 7, the paper's first issue after the quake. This was the text that Wright drafted on 8 Sept. 1923 and referred to in his last letter to Sullivan, written in Los Angeles: “I have written something outlining these views which will appear somewhere perhaps and I am sending it to Tokio to try and head off the propaganda which will try to rebuild Tokio as a modern American city.” Wright to Sullivan, 26 Sept. 1923, in Pfeiffer, Wright: Letters to Architects, 39. (The handwritten dated draft, titled “Why the Skyscraper?” is Frank Lloyd Wright MS no. 437. FLWA.) Wright later praised reinforced concrete's virtues in his “In the Cause of Architecture III: Steel” (1927), in Pfeiffer, Wright: Collected Writings, 1:234–40.

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Figure 13. Architectural Record 53 (Apr. 1923), 343.
Figures 14, 15. Iron Trade Review, 73 (13 Sept. 1923), 716
Figure 16. Japan Advertiser, 13 Apr. 1924, 3
Figures 19 . American Contractor, 44 (29 Dec. 1923), 17
Figure 20. Engineering News-Record 89 (21 Sept. 1922), 477
Figure 21. American Exporter 94 (Feb. 1924), 15
Figure 22. Western Architect 32, no. 4 (Apr. 1923), plate 5
Figure 23. Brown Brothers, Sterling, Penn.