Engineering Industrial Architecture

The Trussed Concrete Steel Company and Albert Kahn

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I. Albert and Julius Kahn's Early Work

Albert Kahn, best known for his pioneering work in industrial architecture, namely designing the factories that housed the early assembly lines for Ford, Packard and General Motors, worked in a noticeably different style than his predecessors. Specifically Albert Kahn transitioned the factory designs from traditional mill construction which was characterized by short beam spans, very dark interiors, and generally heavy timber construction which required at least some skilled labor to industrial architecture and the modern factory as we know it today. The industrial designer George Nelson credits Albert Kahn with transitioning the factory from, "a joy to no one save possibly its owners; it was sooty, ugly, a source of blight wherever it appeared; the condition of its workers was appalling beyond belief" to "the status of architecture" (Nelson 7). Albert Kahn transitioned factory design to an architecture which we would refer to with a capital "A."

This new form of industrial architecture that Albert Kahn championed was characterized by the exact opposite of the traditional mill construction; long beam spans, the ability to place heavy machinery on the top floor, modern day lit factories, and the speed of construction to name but a few things. These changes served to accomplish two main functions for the factory owners. First the new mechanized production processes of the time (i.e. the assembly line) could easily be laid out on the factory floor with plenty of space to reconfigure if necessary. Then along with the increased production from the assembly line, an increase in the productivity of the workers was achieved through "good lighting and ventilation" (Nelson 12). These advances in productivity were credited directly to Albert Kahn's modern day lit factory designs. But how exactly was Albert Kahn able to start constructing buildings in this style? Surely factory owners prior to Henry Ford and the company of his namesake, the Packard Brothers of the Packard Motor Car Company and Alfred P. Sloan of the General Motors Corporation among other industrialists of the time had long desired the benefits inherent in the factories which Albert Kahn was able to produce. What were the engineering innovations behind Albert Kahn's modern factories?

"Behind every good architect is an engineer" is a common sentiment, and this was no different with Albert Kahn. This engineer behind Albert was none other than Albert's younger brother Julius, the junior of Albert by five years. Born in 1874, Julius studied civil engineering at the University of Michigan paid for by Albert and graduated in 1899. After a few years of work on mining operations in Northern Michigan and Japan (Meister 81), Julius made his way back to Detroit to work with his older brother. It is worth noting the significance from Albert Kahn's perspective of working and having an engineer involved so closely with his operations. At the time the current view of the relationship between the architect and engineer, especially from the European perspective of what much has been written, is eloquently described by Le Corbusier, "Let us believe the words of the American Engineers, but let us beware of the American architects" (Banham 15). Many had grown weary of the often times unnecessary design and ornamentation of architects and instead preferred the direct, concise and functional designs that engineers, particularly the American ones, were putting forth. In many ways, Albert's partnership with his younger brother who was studied in the way of "the American Engineer," would later allow him as an architect to design the functionality into his factories that many felt were absent in the architecture of the time.

Upon returning to Detroit and setting up an office in Albert's suite in the Union Trust Building (Meister 81) the two brothers began working together to investigate new methods of reinforcing concrete. Reinforced concrete in 1902 was already a promising new building technology but was accompanied by a number of problems associated with its design and development, not to mention the lack of handbooks on the subject and virtually any reference formulas (Nelson 17). The Kahn brothers must have noted the potential of reinforced concrete and sought to resolve the issues inherent with its use.

According to the architectural historian Chris Meister, the first indications of the Kahn brothers progress in reinforced concrete appeared in the Palms Apartment Building, Detroit in 1902 (Meister 82), figure 1. Due to Albert and Julius pioneering a new system, the method of reinforcing in the Palms Apartment Building was not well publicized. Upon inspection by the city of Detroit there was an expected amount of hesitation and alarm to this previously unproven system of concrete reinforcement. The Detroit News Tribune reported that the city inspector conducted severe tests on the floors by "placing six tons in the weakest place he could find, where one ton is all that will ever be placed on it, in all likelihood, and noting the lack of serious result, he concluded the floors would do." The article concluded by saying, "If anything solider than those floors can be found, Architect Kahn would doubtless like to know about it." (Meister 82).

Figure 1. The Palms Apartment Building (1902).

This aversion to the Kahn's new method of reinforcing concrete was not without warrant. It is safe to say that reinforced concrete was still in its infancy in 1902 and a relatively unproven technology. Given this, human nature tends to naturally be skeptical of something new and untested, especially when it concerns the structural support system of a building. No doubt even more so then when the goal of this new system was to carry heavier loads with smaller concrete beams. In a 1924 speech Albert Kahn gave to the American Concrete Institute on their 20th anniversary he noted this early skepticism to developing new reinforced concrete methods, "Many indeed were the fools who rushed in where angels feared to tread. But fools, men with vision, if you please, are necessary in the progress of mankind and were needed in the development of reinforced concrete. [...] We recall, as with all things new, the serious opposition encountered at the outset from laymen who could not comprehend how a wet mixture of sand, stone and Portland Cement with a certain number of steel rods placed about could carry its own weight, much less heavy live loads" (Kahn 1924). Meister notes that when Julius was asked how he determined the structural design of this new system, he replied “By guess. There are no scientific data” (Meister 83). This lack of any analytical methods in proving early reinforced concrete structures and calming the skeptical minds of laymen was a common problem. Another pioneer of reinforced concrete, Robert Maillart would reportedly walk across his bridges to test them and prove to the public their sturdiness (Structurae). Despite the initial alarm the Palms Apartment Building passed the city inspection and still remains standing today.

Despite the overall positive reaction to the Palms Apartment Building, Julius remained Intrigued and bothered by the inability to precisely calculate the maximum load bearing capacity and mode of failure of concrete floors, beams and columns reinforced with concrete. This was a rather difficult problem given the complexities of not only the behavior of the steel reinforcement but also the concrete into which the steel was imbedded. To begin to address the concrete problem, the American Concrete Institute was created in 1904 to provide standard concrete mix procedures and designs (American Concrete Institute). However it would still be years before any standards of reinforced concrete were to become universally adopted. Noting the potential for new innovations into the reinforced concrete field, Julius Kahn set out to further develop a system of concrete reinforcement that would lend itself to exact structural calculations and alleviate the hesitation regarding its use.

II. The Kahn Bar, The Trussed Concrete Steel Company’s First Product

In the late 1800’s and early 1900’s most concrete reinforcement consisted of either horizontal rods placed in the bottom of the concrete or loose steel stirrups mixed in with the concrete. While these methods did provide reinforcement to the concrete and allow for additional load bearing capacity, they failed through shearing along the lines of principal stresses in the concrete, figure 2, with less than impressive applied loads. Intuitively one could draw the lines of principal sheer but there was no way of calculating how much loading a particular column or beam could take without tests. Additionally the exact pattern that the shearing would exhibit could not be determined without first causing the beam to fail. Finally in areas of large shear oftentimes the steel reinforcing bars would physically slip from the concrete that they were supposed to be supporting. This slippage led to sudden failure in concrete that showed no cracking and was one of the key hesitations to using reinforced concrete.

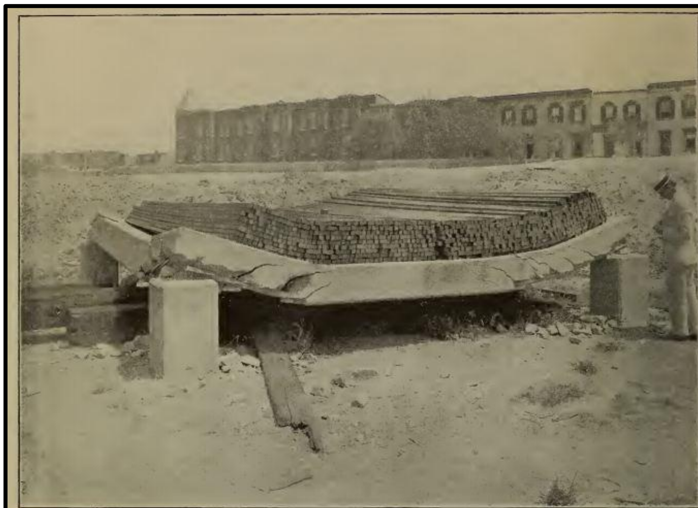


Fig. 6.

Note failure of concrete when horizontal reinforcement only is used. Lines of failure correspond to lines of principal compressive stress.

Figure 2. Concrete Failure Using Traditional Methods of Reinforcement.

Julius Kahn also faced additional considerations when designing his new system. First he had to contend with the loss of skilled laborers available to lay the reinforcing steel. The method had to be straightforward and simple. As had been an emerging trend in America, there was a definite loss of skilled labor available, especially compared to the European craft tradition. Sigfried Giedion notes that “In America materials were plentiful and skilled labor scarce.” Second, given the increasing use of concrete in construction, curing time had to be factored into the construction schedule. The sooner that the concrete reinforcing could be put in place the sooner the concrete could be poured and the sooner the curing period could begin. Therefore an efficient and simple system of concrete reinforcing would be highly desirable in order to make up the time lost compared with traditional wood construction.

These concerns eventually led Julius Kahn to arrive at the design of a “trussed concrete steel reinforcement system,” commonly known as “The Kahn Bar.” The Kahn Bar was certainly a unique design, figure 3, but it proved to be an ingenious method to reinforcing concrete. The most noticeable feature are the bent wings along the length of the bar. These wings were designed to be bent at a 45 degree angle which corresponded to the average angle in the lines of principal shear stresses in a beam. The thinner wings would also serve to transmit the stress downwards to the thicker main reinforcing member. Based on previous research into concrete before Julius began work it was known that concrete was noticeably stronger in compression than tension. As noted in a 1904 document explaining his design Julius states that, “concrete within itself is an excellent material to take up compressive strains, but is comparatively weak for resisting tensile strains” (Trussed Concrete Steel Co. 1904). This knowledge was central to Julius’s design.

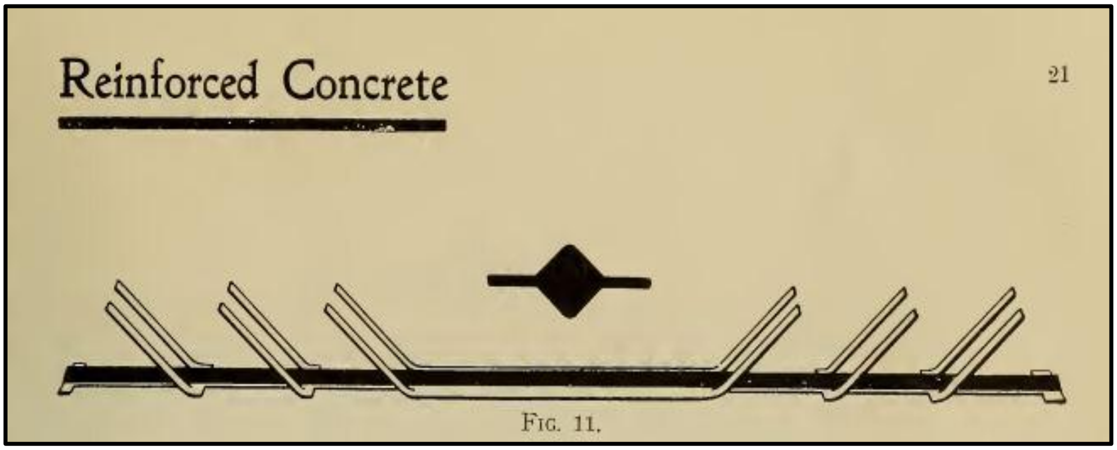


Figure 3. The Kahn Bar.

By designing the winged bars as such the reinforcing steel along the lines of principal tensile strength would serve to strengthen the concrete in its weakest component, tension. Then once the concrete which was poured over the Kahn Bar was set, a Pratt Truss would be formed between the bent wings of the bar and the concrete, figure 4. The concrete that completed the formation of the Pratt Truss would then be in compression. Concrete in compression was quite resistant to shearing. Additionally the bent bars would serve to resist slippage in the concrete under large shear stresses and loadings. As Julius explained, “The Kahn trussed bar is the only known reinforcing bar in which both the shear and tension members are combined in one piece. It is needless to say that the saving in cost of erection alone, due to this fact, warrants the exclusive use of this bar. There is no need to depend upon the proper placing of innumerable small members by careless workmen; no need to risk the life and success upon the exact mixture of concrete by unskilled laborers. In fact, if by accident, frozen or otherwise objectionable concrete is placed in a structure, there still remains a factor of safety of at least 2 or 3. We challenge any other method of construction to show safety values such as these" (Trussed Concrete Steel Co. 1904).

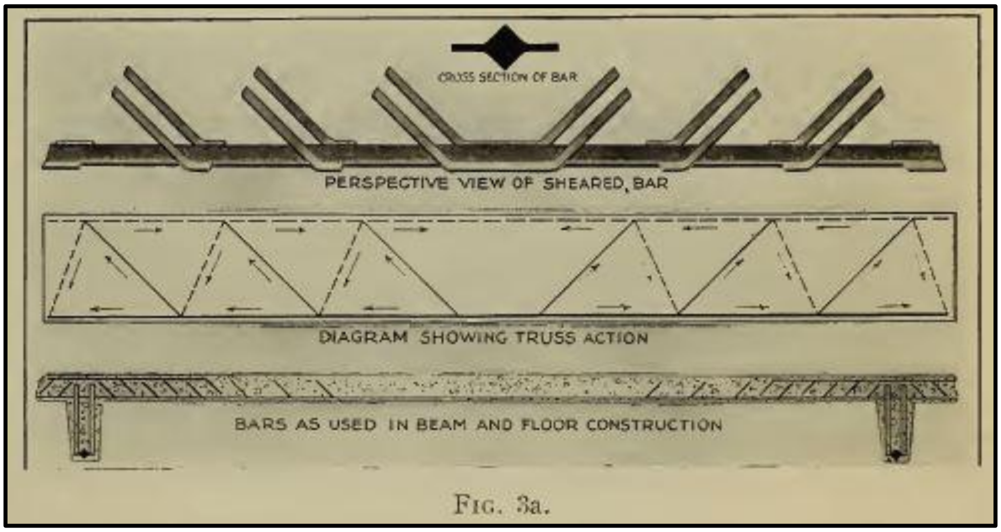


Figure 4. Formation of a Pratt Truss with the Kahn Bar.

Finally and perhaps most importantly with the Kahn Bar Julius developed a system of concrete reinforcing that, when it finally did fail, did so in a manner that allowed for precise calculations of where the failure would occur. By strengthening a concrete beam so well against shearing, the weakest portion of the beam was now the center of the beam. By looking at images of the tests with the Kahn Bar we can observe just this, figure 5. Instead of having numerous cracks along the lines of principal shear in the beam, the Kahn Bar failed with a concise vertical crack in the center of the beam with the beam failing in tension. And with the beam now failing in tension, it was shown that the full strength of the steel was developed, a key advancement (Trussed Concrete Steel Co. 1913). The importance of being able to mathematically explain the beam's failure is echoed again by Le Corbusier in saying, "Let us believe the words of the American Engineers" (Banham 15). This was a key advancement in the use of reinforced concrete. In a 1913 paper Julius Kahn proudly exclaimed that after studying "the question of reinforcing and finishing concrete [he has] brought the subject down to an exact science" (Trussed Concrete Steel Co. 1913). So important were these calculations that in his 1924 speech to the American Concrete Institute Albert Kahn himself stated that these "methods of [reinforced concrete] computation […] were one of the important contributions of America” (Kahn 1924). Indeed a milestone had been achieved in reinforced concrete construction.

FIG. 10.

Failure of two Kahn reinforced beams
Load: Pig iron 101100 lbs.
Weight of floor slab 9300 lbs.

Total weight on beams 110400 lbs.
Beam failed in center pulling four bars of steel in two. Compare with Fig. 6.

Figure 5. Concrete Failure Using the Kahn Bar for Reinforcement.

The technical design of the Kahn Bar allowed for drastically larger loads to be carried by concrete reinforced with this method. Comparing the difference in loading shown in figure 2 verse figure 5 visually confirms this. The Kahn Bar’s superiority was scientifically confirmed by tests performed at the University of Wisconsin under the supervision of Martin O. Withey around 1906. Compared to the current methods of reinforcing with loose stirrups, the Kahn bars carried on average 33% more load and reached upwards of 85% of the ultimate strength of the steel (Trussed Concrete Steel Co. 1913).

Julius was granted a patent for his method of “Concrete and Metal Construction” in August 1903 (Kahn, Julius *Concrete and Metal Construction*). He initially planned on leasing the design to Albert, marketing the design to builders out east, and then moving on to other ventures (Meister 86). However after a business trip to the east coast Julius became discouraged by the ease with which the Kahn Bar could be copied. Motivated by this concern Julius decided to market and sell the Kahn Bar himself. In 1903 Julius formed the Trussed Concrete Steel Company in Detroit with a steel yard in Youngstown, Ohio.

III. The Trussed Concrete Steel Company Takes Shape

For the next decade the Trussed Concrete Steel Company enjoyed remarkable growth. It should be noted here that the company did not adopt the "Truscon" moniker until 1921 when the name was changed to the Truscon Steel Company. The company soon began to develop a wide array of steel building material that were found on nearly every type of building the world over. By 1914 the TRUSCON Company was worth over $2 million and was used in over 15,000 structures (Trussed Concrete Steel Co. 1913).

Trussed Concrete Steel Company Offices quickly sprung up in offices nationwide and soon worldwide. From when Julius patented the Kahn bar to this initial period of expansion the company's main, if not their only product, would still have been the Kahn Bar. Aside from the previously noted advantages of using the Kahn bar for reinforced concrete construction, another key advantage of the Kahn bar would soon become apparent. By 1906 the use of the Kahn bar had made its way from the Midwest out to San Francisco. In San Francisco at the time only a few buildings were constructed with reinforced concrete due to the influence of brick layer labor unions (Trussed Concrete Steel Co. 1913). However upon the San Francisco earthquake of April 18, 1906 and subsequent fire very few buildings other than those constructed with the Kahn Bar stood standing (Siri P. 82). One of these buildings, the Bekins Van and Storage Co. Building became a poster child for the Kahn Bar's earthquake and fire resistance, figure 6**.** It was soon recognized that the Kahn Bar's tensile strength gave the concrete great coherence and high elasticity, thus making it ideal for earthquake resistance.

Figure 6. The Van Bekins Building in the aftermath of the 1906 San Francisco Earthquake. Note the Building was only Constructed to the Second Floor at the Time of the Earthquake.

Structures engineered with the Kahn Bar soon became extremely popular in regions experiencing seismic activity. As was documented in a number of different occasions an earthquake would devastate an entire city save for one or two structures built with the Kahn Bar. Seeing these few remaining structures amidst the ruined city proved to be great publicity for the Trussed Concrete Steel Company. Upon the rebuilding process most commercial buildings would then specify the engineering services of the Trussed Concrete Steel Company. Instances of this inadvertent publicity campaign occurred from earthquakes in Calabria, Italy (1905), Messina, Italy (1907), Jamaica (1907), and the Mount Taal eruption in the Philippines (1911) (Trussed Concrete Steel Company 1913).

In addition to having offices in principal cities throughout the U.S., the Trussed Concrete Steel Company set up oversees offices in England and Japan. In 1905 Moritz Kahn was tasked with setting up the London offices (TRUSCON P.7) while Julius himself made the trips to Tokyo in 1910 to establish the company there (Siri P. 89). These offices both soon expanded to include steel yards throughout their respective area. The Japan office in particular soon had offices in Osaka, Nagoya, Fukuoka and Kawasaki. Besides being used in thousands of structures in both countries, the Kahn Bar was used in notable structures such as Frank Lloyd Wright's

Imperial Hotel in Tokyo (Siri P. 90) and in the reconstruction of the Jewel Room in the Tower of London (TRUSCON P. 11). Clearly the strength, fireproofing and ease of installation made the Kahn Bar just as attractive to international architects as it did to American ones, whether industrial or otherwise.

Aside from the technical superiority of the Kahn Bar over other systems of steel reinforcing at the time the Kahn Bar was also a proprietary system. According to Mr. Donald Bauman, the Manager of Specifications at Albert Kahn Associates, since Julius patented the Kahn bar in 1903 he would have had exclusive rights to this system and its uses until 1923. As evidenced by the number of structures around the world that used the Kahn bar in the early part of the 20th century, Julius clearly put this patent to good use. By 1923 when the patent for the Kahn bar expired the Trussed Concrete Steel Company had become a dominant figure in concrete reinforcement the world over and as is detailed below, had expanded their market share to include a full range of steel building products for both commercial and residential uses.

IV. The Breadth of the Trussed Concrete Steel Companies Product Line

Julius Kahn's first foray into the steel building products market was with the Kahn Bar produced at the Trussed Concrete Steel Companies steel yard in Youngstown, Ohio. Soon thereafter Julius must have noticed the immense potential that additional steel building products could have in the construction industry, particularly for factories. These additional steel building products would address similar issues in building construction that had made the Kahn Bar so popular; strength, ease of construction, and being fire and vibration proof. With the already successful Kahn Bar it would not have been hard to develop other products under the Trussed Concrete Steel Companies name and engineering knowledge. Furthermore the company already had a foundry and steel yard in Youngstown with which to manufacture from, figure 7.

Figure 7. The Trussed Concrete Steel Company Steel Yard in Youngstown, Ohio.

Based on Trussed Concrete Steel Company product manuals from 1913 one can easily see the extent with which the company developed their steel building product line and even into materials beyond steel (Trussed Concrete Steel Co. 1913). This desire to continually invent new engineering designs and ideas is recognized to this day at the headquarters of Albert Kahn Associates. Proudly on display in the building is a plaque for the *Julius Award for Excellence and Innovation,* awarded to the employee who advances innovation in the company. A brief history of the award at the bottom of the plaque states that “from 1903-1940, 74 patents were issued in [Julius’s] name. Scores of others issued in the names of his employees bear the imprint of his versatile mind” (Julius Award for Excellence and Innovation). The following table highlights some of the building products invented by Julius Kahn and his employees of the Trussed Concrete Steel Company by 1913, table 1.

Product	Use
The Kahn Trussed Bar	Concrete Reinforcement
Rib Metal	A bar reinforcement method placed in concrete slabs. Essentially reinforcement handled as one large sheet of bars
Built-up Column Hooping	Column Reinforcement
Rib Bars	Auxillary Reinforcing to the Kahn Trussed Bar, Rib Metal, and Hy Rib wherever direct tension or compression stresses are to be resisted
Hy-Rib	Steel Sheathing
Hy-Rib Bender	Bends Hy-Rib Sheets
Hy-Rib Punch	Fastens Sheets of Hy-Rib together
Hy-Rib Cutter	Cuts sheets of Hy-Rib
Rib-Lath	Steel Lath
Rib Studs	Studs
United Steel Sash	Glazing for windows, sidings for walls and roofs
Trus-Con Inserts	Inserts for Adjustable Inserts
Trus-Con Curb bars	Protects exposed concrete
Trus-Con Armor Plates	Protects the expansion joints in concrete roads from chipping off and breaking down
Trus-Con Expansion Joints	Connections between pavement slabs
Hollow Tile	Flooring
Joist Hangers	Hangers which attach to adjustable Inserts
Post Caps	Attachements for the end of adjustable inserts
Centering Clamps	Clamps for adjustable inserts
Steel Floredomes	Rectangular dome-shaped steel tiles open on the underside
Steel Floretyles	Deeply corrugated steel tiles open on the underside
Collapsible Column Hooping	Reinforcing concrete columns
Trus_Con Pressed Steel Slotted Inserts	Hangers to attach shafts, fixtures, sprinkler systems, etc
Kahn Adjustable Inserts	Hangers to be used with the slotted inserts
Trus-Con Socket Inserts	Used to hide unused holes for the slotted inserts
Rib Steel Stair Treads	Grip and wear resistant steel treads for stairs

Table 1. Trussed Concrete Steel Company Building Products in 1913

By 1913 aside from the Trussed Concrete Steel Companies principal offices in Detroit and Youngstown, steel yard in Youngstown and sales offices throughout the U.S., England and Japan, the company had a chemical laboratory in Detroit. The purpose of this division was to develop a full range of chemicals with which to treat, finish and waterproof the buildings built with the company's steel and concrete products. These chemical products are summarized in Table 2.

Product	Use
Por-Seal	Damp-proofing
Stone-Tex	Damp-proofing
Stone backing	Damp-proofing
Plaster Bond	Damp-proofing
Water Proofing Paste	Water-proofing
Asepticote	Enamels and Interior Finishes
Sno-Wite	Enamels and Interior Finishes
Industrial Enamel	Enamels and Interior Finishes
Hospital Enamel	Enamels and Interior Finishes
Dairy Enamel	Enamels and Interior Finishes
Floor Finish	Enamels and Interior Finishes
Alkali-Proof Wall Size	Enamels and Interior Finishes
Edelweiss	Enamels and Interior Finishes
Floor Enamel	Enamels and Interior Finishes
Bar-Ox No. 7	Iron and Steel Protection
Bar-Ox No. 14	Iron and Steel Protection
Bar-Ox No. 21	Iron and Steel Protection
Bar-Ox No. 28	Iron and Steel Protection
Roof-Seal	Roof Protection
Ironite Flooring	Floor Protection
Water Proofed Cement Stucco	Siding Protection

Table 2. Trussed Concrete Steel Company Chemical Products in 1913

What these Trussed Concrete Steel Company products allowed for in terms of building construction and specifically industrial architecture, a more in depth discussion of a few of the more notable and widely used products is needed. Due to the space of this paper and wishing to focus on those products relevant to the architecture of Albert Kahn, Hy-Rib, the Kahn System and Industrial Steel Sash will be discussed.

V. Hy-Rib, Lightweight Concrete Floors and Roofs

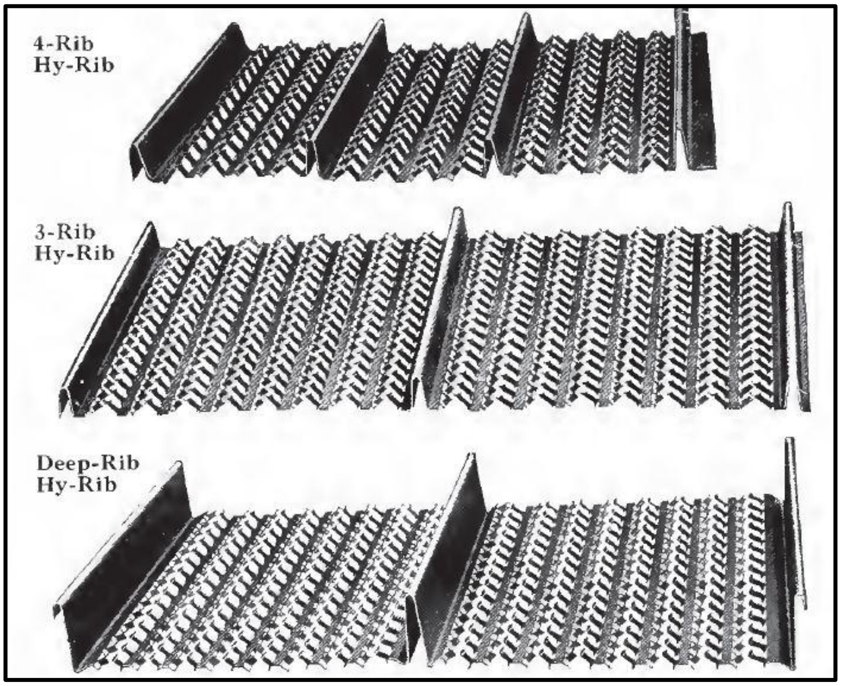


Figure 8. Hy-Rib

Hy-Rib, developed in 1909 (TRUSCON: The First Fifty Years) likely evolved out of a desire to reinforce floors and roofs in a similar method to the Kahn Bar in beams and columns, figure 8. Hy-Rib is composed of a steel sheathing which is stiffened by rigid high ribs and manufactured out of a single sheet of steel thereby making a complete unit of lath and studs (Trussed Concrete Steel Co. 1913). This design did away with expensive field labor and form work since the concrete and plaster, which the Hy-Rib would be embedded within, could be applied directly to the steel. The concrete or plaster would “flow through the lath surface only enough to secure a perfect clinch on the steel,” figures 9 and 10. Following the general theme of other Trussed Concrete Steel Company products this would allow for a much more economical and fireproof construction than could be achieved with wood.

Plastering underside of Hy-Rib after being concreted above.
View taken at Hotel Tuller, Detroit.

Figure 9. Hy-Rib Plastering.

Arched Hy-Rib Floor in Joseph Bendt Store, Kenosha, Wis.,
used in conjunction with reinforced concrete beams.

Figure 10. Hy-Rib Concreting.

The first use of Hy-Rib was in flooring owing to its ability to quickly interlock and then have plaster applied to the underside (which would be the ceiling) and have concrete poured on the top (which would form the floor). If heavy loads were required on the floor the Hy-Rib could easily be bent into an arch and then concrete poured as usual to provide the additional required strength, figure 11.

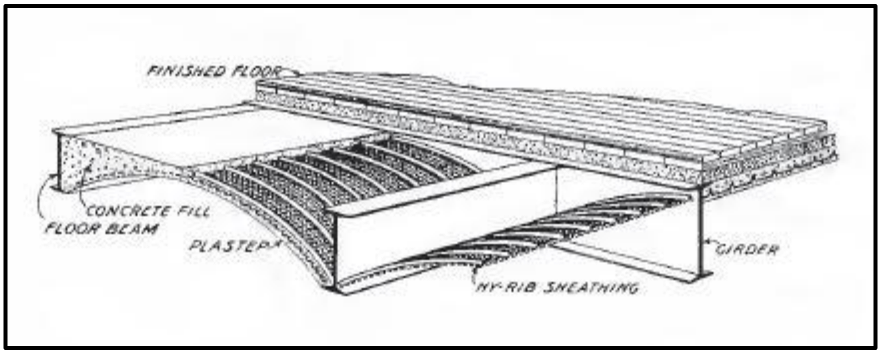
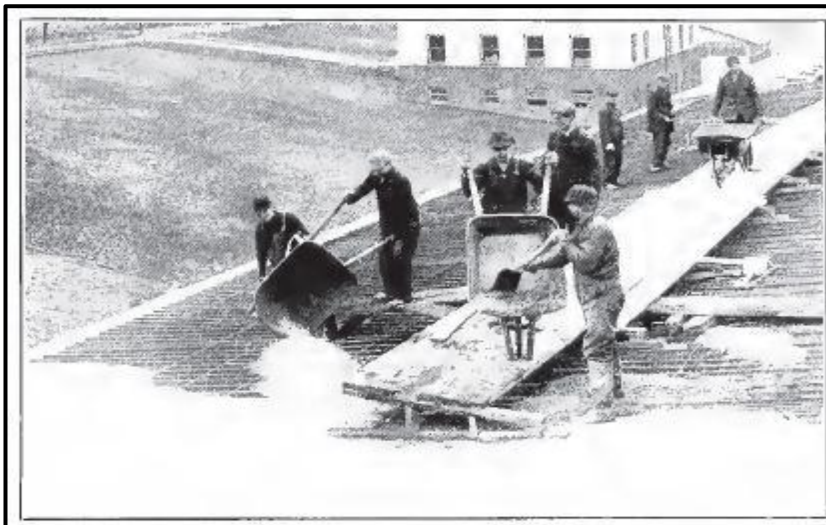


Figure 11. Hy-Rib Arched Floor Construction.

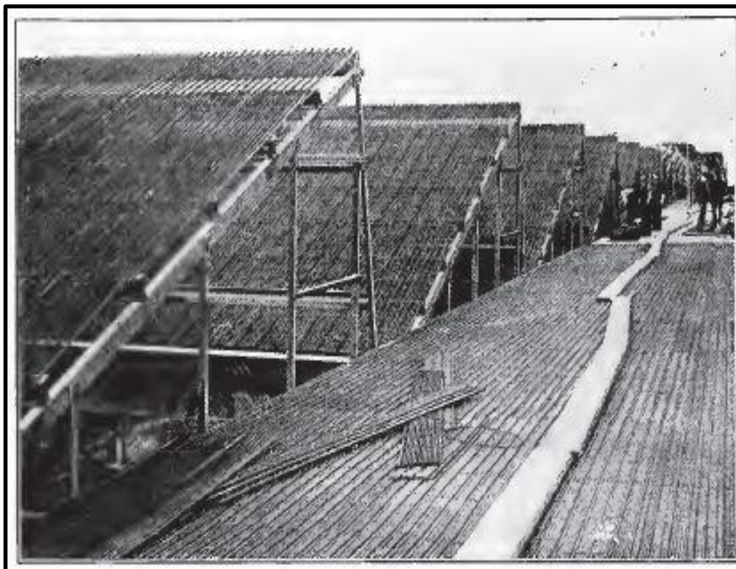
The use of Hy-Rib was also extremely important in roofs. Previously concrete had been too expensive to use on roofs owing to the difficulty of erecting form work 20 - 50 feet above ground. Therefore corrugated iron sheets had been primarily used. These however proved unsatisfactory because they would leak and rust out after a short time. Roofs constructed with Hy-Rib resolved these issues. The Trussed Concrete Steel Company manual notes that "the construction of roofs is similar to that of floors except that the loads are lighter and a correspondingly lighter construction is desirable" (Trussed Concrete Steel Co. 1913). In a similar method to floor construction, the use of Hy-Rib did away with the use of form work 50 feet above the ground and since the Hy-Rib reinforced the concrete, thinner concrete slabs were required on the roofs, figure 12. This in turn then reduced the weight and cost of roof trusses.



Concreting Deep-Rib **Hy-Rib** on one of the buildings at our Youngstown Plant.

Figure 12. Concreting a Hy-Rib Roof.

One of the best examples of the use of Hy-Rib can be seen in the construction of the well-known saw tooth roof profile. The small amount of concrete which was needed on saw tooth roofs and the ease with which the poured concrete could adhere to the inclined Hy-Rib sections made the saw tooth roof construction particularly easy. The use of saw tooth roofs provided for ventilation and lighting inside of factories, a style that Albert Kahn used quite frequently, figure 13 and 14.



Hy-Rib Saw-tooth Roofs, Oliver Chilled Plow Co., Hamilton. Ont.
David Dickinson, Contractor. Prack & Perrine, Architects.

Figure 13. Saw Tooth Roof Profile.

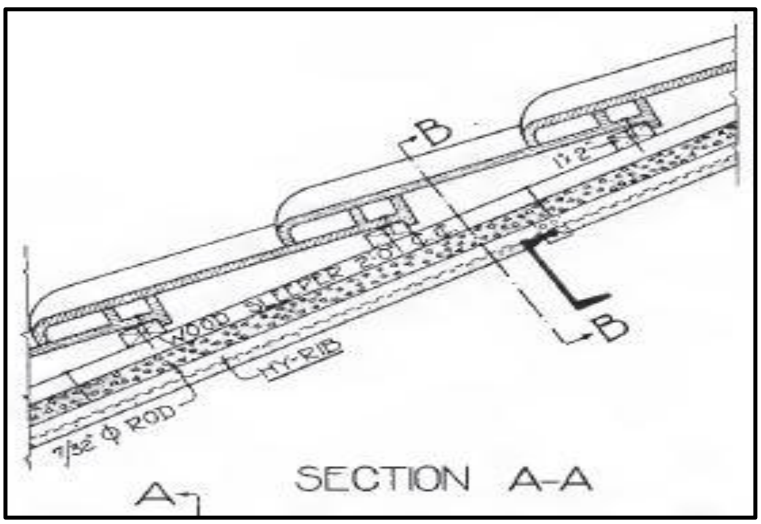


Figure 14. Hy-Rib Saw Tooth Roof Drawing.

VI. The Kahn System of Hollow Tile Floor Construction

Though the use of arched Hy-Rib in floor construction permitted for strong floors to be constructed quickly, factories sometimes required additional strength and suppression of vibrations in their floors. This was often the case when heavy machinery and assembly lines were situated on upper floors in factories. This increase in the live loads acting on the floors required the floors themselves to become thicker and heavier as a result. Finally the heavier dead loads of the floors then required much larger columns to support the floors. Factory owners soon became concerned with these larger columns taking up more and more precious area on the factory floor (Trussed Concrete Steel Co. 1913).

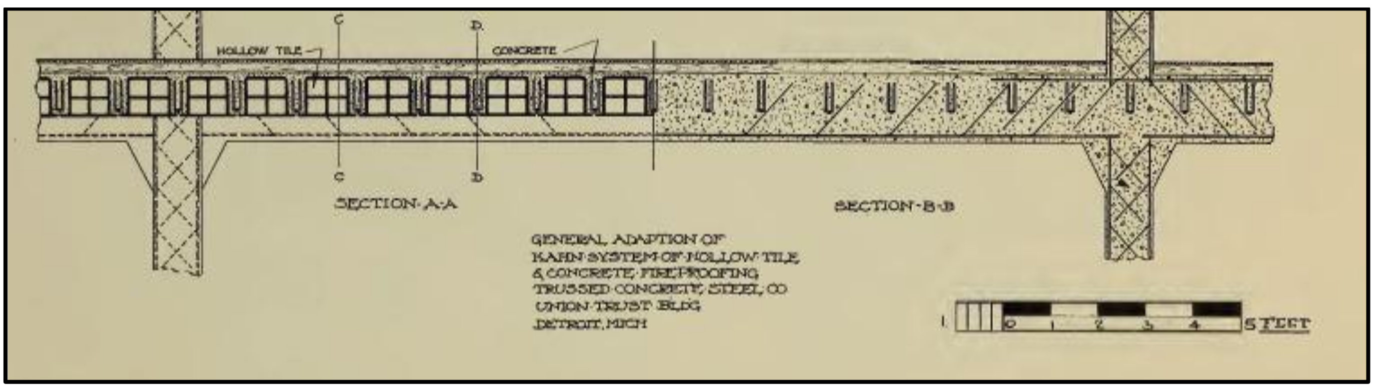


Figure 15. The Kahn System of Hollow Tile Floor Construction.

From these concerns evolved the Kahn System of hollow tile floor construction, figure 15. The word “system” is used here because the Kahn hollow tile floor construction was actually a system that involved additional Trussed Concrete Steel Company products. Once a layer of Hy-Rib was laid down to form the ceiling of the floor underneath and a thin layer of concrete was poured over the top of the Hy-Rib, hollow tile blocks were laid in rows with a 3 – 4 inch space between them. In the spaces Kahn Bars were then placed and eventually poured over with concrete, figure 16. With the Kahn System “the tile [served] merely as filling empty spaces, the floor weight [was] carried directly by the intermediate beams” (Trussed Concrete Steel Co. 1904). With the intermediate beams carrying most of the load and a large portion of the floor being hollow tile, the size of the columns could then be reduced. Additionally with much of the floor being made up of dead air space, the Kahn System had a remarkable vibration reducing ability. So convinced was the Trussed Concrete Steel Company of the strength of the Kahn System that they agreed “to test any of [their] floors to twice their safe carrying capacity without undue deflection” (Trussed Concrete Steel Co. 1904).

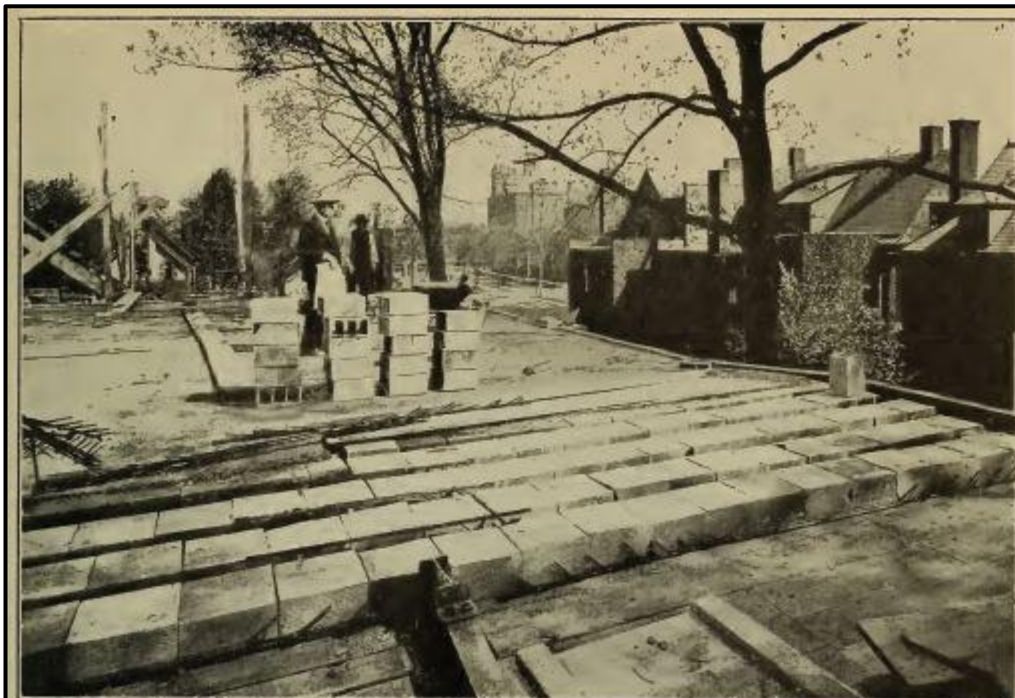


FIG. 20.
Method of laying Kahn System of Reinforced Hollow Tile Construction. Lay tile dry, in rows about 16″ o. c. Then insert one Kahn Trussed Bar in each space between these rows of tile, and fil with 1:2:4 concrete.

Figure 16. The Kahn System of Hollow Tile Floor Construction being Constructed.

VII. United Steel Sash, Steel Window Sash

Figure 17. United Steel Sash.

Another concern with previous mill type factory construction was the minimal light that entered that building. With previously mentioned Trussed Concrete Steel Company products such as the Kahn Bar and the Kahn System, the exterior walls of such factories were no longer needed as the primary load bearing elements of the building. As such the exterior walls could become not only thinner but larger and larger openings could be cut into the walls into which larger windows could be placed.

The United Steel Sash produced by the Trussed Concrete Steel Company, figure 17 was designed to fit easily into these larger window openings and connect with other Trussed Concrete Steel Company products in the walls. Though windows in factories were nothing new (although small), United Steel Sash allowed the much sought after window openings to be free of any obstructions such as muntins, mullions, lintels and jambs (United Steel Sash). The Trussed Concrete Steel Company promised that with this increased and unobstructed light entering the factories "full efficiency of every workman is assured," a key consideration of factory owners such. Furthermore United Steel Sash windows were designed to be opened at numerous points to provide maximum ventilation, figure 18. Being steel the window sash was also weather and fire proof.

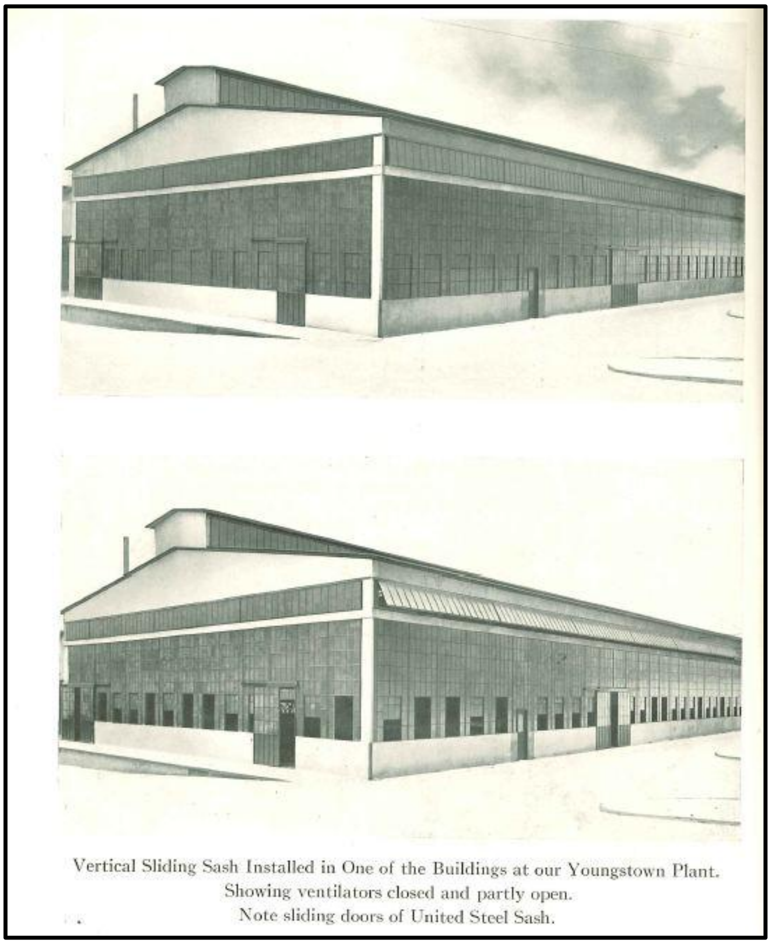


Figure 18. United Steel Sash Ventilation Ability.

VIII. The Trussed Concrete Steel Company Products as a Complete Building System

As previously alluded to, part of the genius and success of what Julius Kahn did with the Trussed Concrete Steel Company was to provide a complete range of building products that could and often were required to be used together. This is evident when looking through the company's product manuals. Each product is placed in a natural progression of where and when it would be used in the construction process; beginning with the Kahn Bar and ending with the range of chemical products. Additionally one can imagine the savings in cost associated with buying and shipping all of the steel for a building project from a single company. And if this wasn't reason enough, the Trussed Concrete Steel Company product manuals are full of references to the company's engineers offering their services and drawings free of charge to any customer. Clients who elected to use the Trussed Concrete Steel Company to construct their buildings were greeted to a full line of well-regarded building products and excellent engineering services. The connections to the architecture of Albert Kahn also probably did not hurt their cause either, figure 19. As an example of the Trussed Concrete Steel Companies ability to supply an entire range of building materials, one needs to look no further than the Packard Plant, Detroit; Particularly Packard #10.

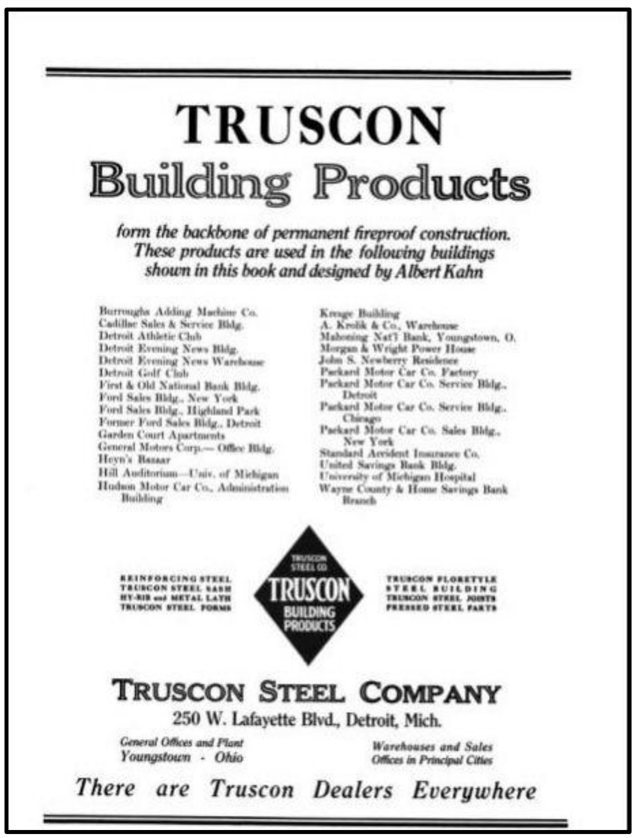


Figure 19. Truscon Steel Company Advertisement in a Publication by the Albert Kahn Firm (1921).

IX. The Histories of the Trussed Concrete Steel Company and the Packard Plant

Though the Palms Apartment Building (1902) is credited with being the first building by Albert Kahn to use reinforced concrete, the first industrial building to use reinforced concrete was Packard #10 (1910). As noted by the architectural historian Chris Meister, Albert and Julius were well acquainted with Henry B. Joy, the manager of the Packard Company at the time. Years earlier Joy had commissioned Albert to remodel a private residence for himself as well as design a factory for the Superior Match Company in the traditional mill type construction. For Joy it would only be fitting to hire the Kahn brothers to design Packard #10, utilizing the full range of the Trussed Concrete Steel Companies products.

Completed in 1910 the Packard Plant very successfully demonstrated the potentials of what Albert Kahn could achieve as an architect, utilizing steel building products from his brother's Trussed Concrete Steel Company. The figures below (figures 20 and 21) aim to provide the reader with an idea of the extent to which Trussed Concrete Steel products were used throughout Packard. Scans of Albert Kahn's original drawings from Packard #10 were used from the Bentley Historical Library at the University of Michigan. Overlain on these scans are schematic drawings of Trussed Concrete Steel Company products from the company's product manuals. Additionally photographs of Packard #10 as it stands today were overlain to provide a sense of the appearance of the building.

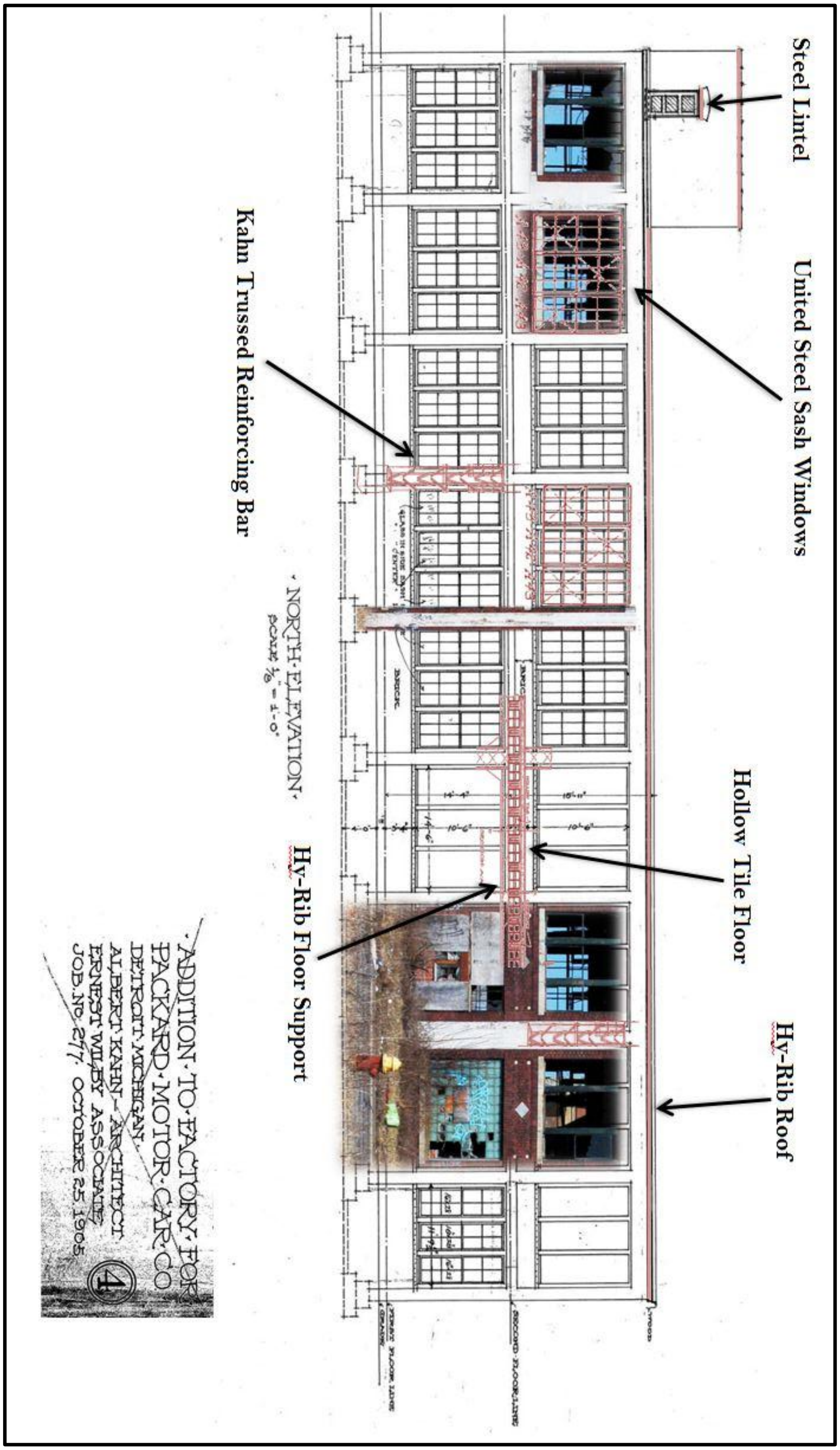


Figure 20. Trussed Concrete Steel Company Products Used in Packard #10, Elevation View.

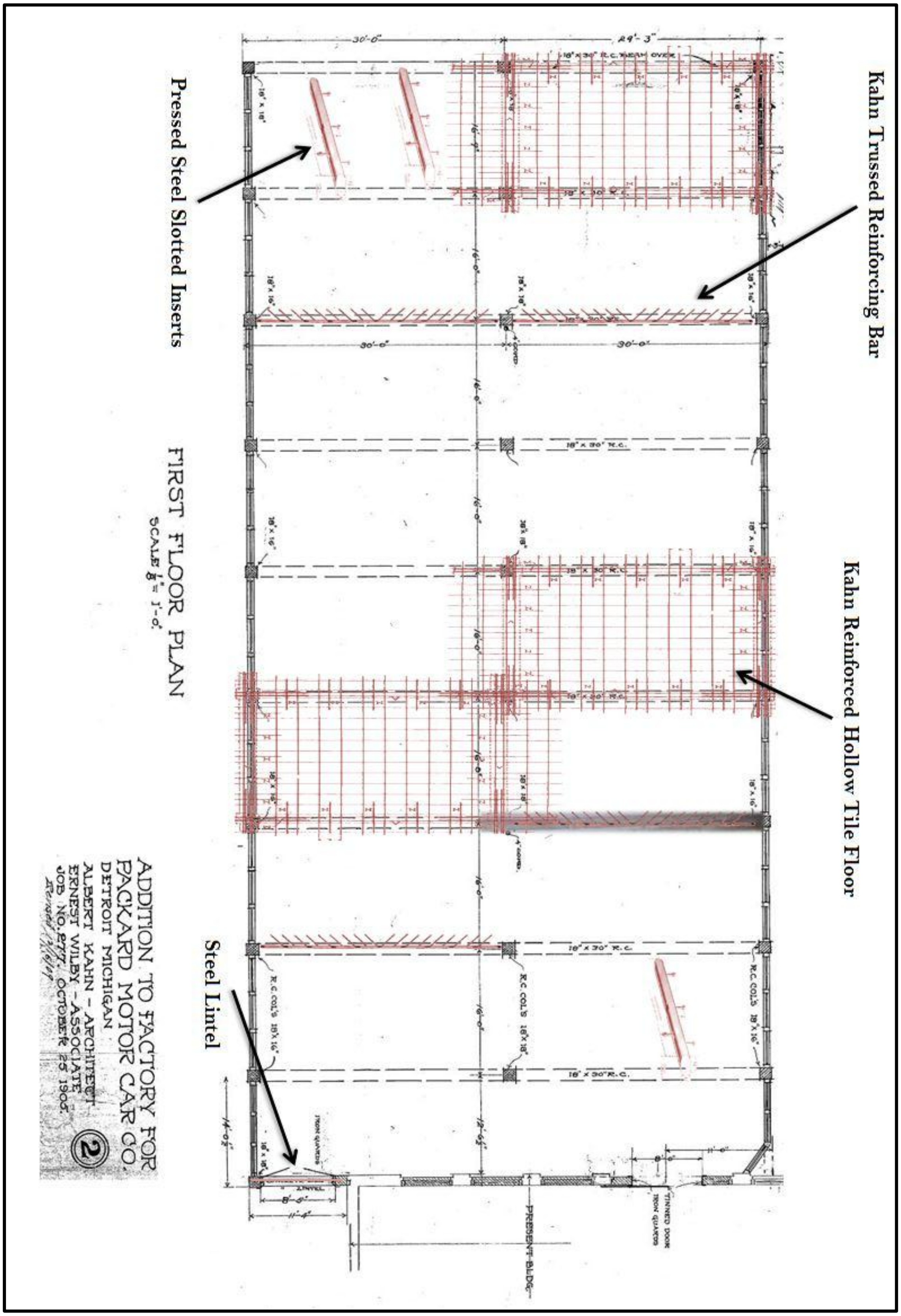


Figure 21. Trussed Concrete Steel Company Products Used in Packard #10, Plan View.

X. The Trussed Concrete Steel Company and the Packard Plant Today

Locating buildings designed by Albert Kahn with which to study in person is a rather trivial matter given the sheer number that he designed in the Ann Arbor and Detroit area. The Albert Kahn firm designed over 900 buildings in the Detroit alone. However this is an entirely different story when trying to study the products of the Trussed Concrete Steel Company. Since most of the Trussed Concrete Steel Company's building products were used in the frames of buildings, finding examples of say the Kahn Bar proves to be rather difficult. Choosing to focus on Packard #10 thus presents a unique opportunity given the financial crisis that the city of Detroit currently finds itself in.

When visiting the Packard Plant one finds themselves in a stark, postindustrial landscape, taken to the extreme. Given no context for the current state and disrepair of the Packard Plant one would be left to think that the place has been thoroughly bombed, figures 22 and 23. Though undoubtedly an unfortunate site to see an Albert Kahn building and at one time such a major part of the city in such a decrepit state, therein lays a unique opportunity to discover the inner workings of the once mighty factory. This is where we find the Trussed Concrete Steel Company's innovations.

Figure 22. The Current State of the Packard Plant.

Figure 23. The postindustrial Landscape of the Packard Plant.

Littered throughout the wreckage of the once mighty Packard Plant a discerning eye can easily spot the remains of the Trussed Concrete Steel Company. The Kahn Bar, once the most novel and strongest of any concrete reinforcement lays mangled and twisted, bent grossly out of shape. What little of the bar remains is either too rusted out or too embedded in concrete to be of any value to the scrappers who frequent the site, figure 24.

Figure 24. The Kahn Bar in situ.

The remains of the Kahn System of Hollow Tile floor construction can be seen scattered in piles throughout the floor. Glancing overhead one sees pockets in the ceiling which the hollow tiles once inhibited, providing the sturdiest of floors for the early assembly lines, figure 25.

Figure 25. The Kahn System in situ.

And finally perhaps the most prodigiously visible of the Trussed Concrete Steel Companies products about the Packard Plant is Hy-Rib. Examples of Hy-Rib still clinging desperately to the crumbling and cracking concrete that it has supported for the last 100+ years are a common site, figure 26.

Figure 26. Hy-Rib in situ.

XI. A Context for the Trussed Concrete Steel Company and the Packard Plant

Though one can be quick to write off the wreckage of the Packard Plant as simply a relic of the industrial past - the remains of an architectural building style and construction techniques that quickly outlived their usefulness – the past and present of the Packard buildings tell a different story.

When Packard #10 was constructed in 1910 it was the tenth factory type building that Albert Kahn had built of the Packard Company. But all the previous buildings had been constructed in the ways of the mill type construction; short spanned wooden beams, dark interiors, heavy floors, etc. The Packard #10 building was the first to utilize reinforced concrete with Julius Kahn's Kahn Bar but also as previously discussed, the full range of steel building products from the Trussed Concrete Steel Company.

Using the Trussed Concrete Steel Company's building products in Packard #10 turned out to literally be night and day to the previously constructed Packard buildings. The first nine Packard buildings constructed in the mill type construction had spans of 12 – 14 feet. Packard #10 on the other hand had massive 32 foot spans, figure 27. The sudden opening up of the interior of the factory with the less jumbled floor space from fewer and farther spaced columns, to the massive windows now permitted on the exterior walls flooding the factory floor with light must have been a completely illuminating experience those who worked at Packard.

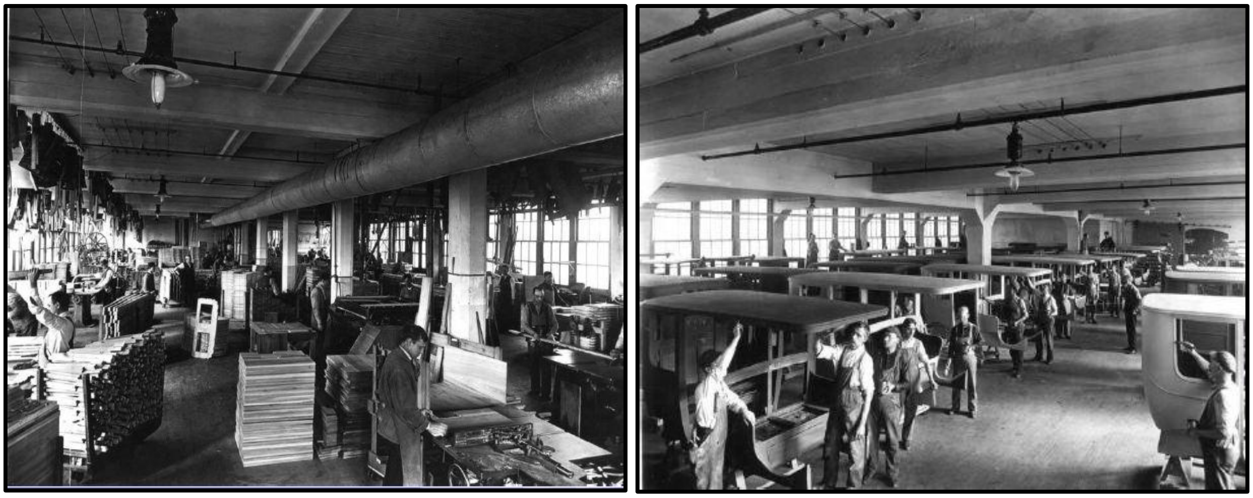


Figure 27. The Interiors of Packard buildings #1-9 (Left) and the Interior of Packard #10 (Right).

The construction and appearance of the Packard #10 was so well regarded by the company that soon thereafter the original nine buildings were entirely renovated and rebuilt with the designs of Albert Kahn and the products of the Trussed Concrete Steel Company. Additionally all of the 92 buildings that were eventually constructed at the Packard site used the Trussed Concrete Steel Company products, figure 28 and 29. So popular was the Trussed Concrete Steel Company's system of reinforcing concrete that a 1912 Trussed Concrete Steel Company advertisement stated that "During the past two years manufacturing plants with an aggregate of over 30 acres of floor space have been built according to the Kahn System of reinforced concrete for the automobile industry alone" (Kahn System of Reinforced Concrete). The technical innovations in reinforced concrete factories that were first debuted in Packard #10 soon became the standard for automobile factories across America. Furthermore after the Packard construction Albert and Julius Kahn stated to the Detroit Free Press that they "were making a specialty of heavy factory and mill construction, paying special attention to working out the details of difficult engineering and architectural propositions" (Meister 86).

Figure 28. The Extent of the Packard Plant

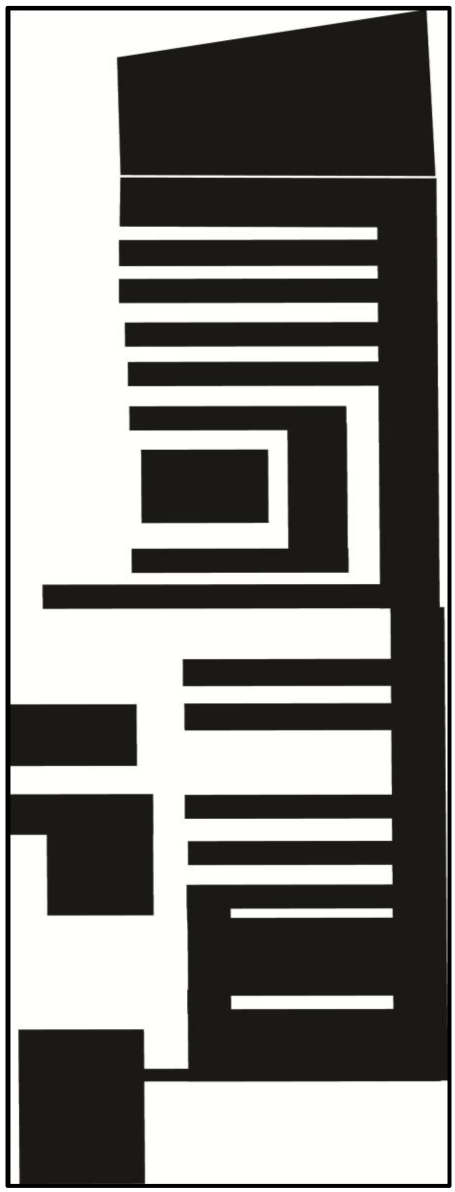


Figure 29. The Layout of the 92 Buildings of the Packard Plant, Courtesy of Catharine Pyenson

XII. The Legacy of the Trussed Concrete Steel Company in the Packard Plant

One hundred years later after the might of the American automobile industry has moved on, the factories that once housed the assembly of the early automobiles no longer needed, and the Packard Car Company no longer a household name, the Packard Plant refuses to be forgotten. The Packard plant, Packard #10 included, is now generally regarded as an eyesore by the City of Detroit; of interest to only hipsters, graffiti artists, scrappers and the occasional architect. In the early 1990's the city of Detroit attempted unsuccessfully to take a wrecking ball to the buildings. They soon realized that the construction of the Packard Plant, with Trussed Concrete Steel Company products at its core, was immensely stronger than any industrial buildings that would have been constructed in the present time. John Adamo Jr. an engineer and CEO of Adamo Group, a demolition contractor in Detroit, noted that "the level of effort to take down a building in this era versus a similar building that would have been built 50 years later is night and day. Factories built in the early 1900's were overbuilt – using more concrete and steel than was necessary, but intended to accommodate expansion as the automobile industry grew. Demolition [of the Packard Plant] could take a year and well over $20 million" (Dixon).

Given the current financial blight of Detroit and the shear strength of the Packard Plant, the building and the presence of the Trussed Concrete Steel Company products will not be going anywhere anytime soon. It is slightly ironic that 100 years earlier Julius Kahn proudly remarked that Packard #10 contained "the strongest system of reinforced concrete on the market today" (Trussed Concrete Steel Co. 1913). Whether for better or worse the Packard Plant will remain standing for the foreseeable future, perhaps the best testament of any to the engineering of Julius Kahn and the Trussed Concrete Steel Company.

XIII. The Disappearance of the Trussed Concrete Steel Company

The designs and engineering of the Trussed Concrete Steel Company were wildly successful and profitable during the first decades of the 20th century. Yet what became of the Kahn Bar and the Kahn System, among the company's other innovations? Present day methods of concrete reinforcement are drastically different in appearance than the Kahn Bar. Where has history swept over the Trussed Concrete Steel Company?

The first places to look are the patents for the designs used by the Trussed Concrete Steel Company. As previously mentioned Julius Kahn was awarded a patent in 1903 for the Kahn Bar. The Kahn method of reinforcing concrete would be a proprietary system for the next 20 years. Additionally the Kahn Bar was the Trussed Concrete Steel Company's first product and really the backbone of all future products as most of the later engineering systems were designed to work with the Kahn Bar. Hence studying the history of the Kahn Bar likely will provide clues to the Trussed Concrete Steel Company as a whole.

During these 20 years the company certainly capitalized on their proprietary system. Yet 20 years is a long time when talking about a market share. Chances are during this time other cheaper non-proprietary concrete reinforcing systems were developed. According to Dr. James Wight, professor of civil engineering at the University of Michigan and current president of the American Concrete Institute, nothing was flawed in the design and engineering of the Kahn Bar, it would simply prove too complicated to manufacture in the long run (Wight). Though the Kahn Bar was manufactured by the Trussed Concrete Steel Company in standard lengths, figure 30, every different length bar, column or floor slab that needed reinforcing would need to have its own specially manufactured bar. There was no interchangeability between lengths.

Tables giving sizes and reinforcement for square panels, according to the Kahn System of Reinforced Concrete

Type II

Panel 20′ x 20′ between Supports

Safe Live Load in lbs. per sq. ft.	Beam A			Beam B			Floor Slab			Pounds of steel per sq. ft.		Cubic feet of Concrete per sq. ft.
	b	d	Steel	b	d	Steel	t	s	Trus. Con. Bars	T	K	
150	12	24	2–1¼″ x 3¾″	8	19	2–¾″x2 3/16″	4″	12″	½″	1.62	2.30	0.58
175	12	28	2–1¼″ x 3¾″	8	22	2–¾″x2 3/16″	4″	10″	½″	1.94	2.30	0.63
200	16	22	3–1¼″ x 3¾″	10	14	2–1″x3″	4″	9″	½″	2.16	3.41	0.60
225	16	24	3–1¼″ x 3¾″	10	16	2–1″x3″	4″	8″	½″	2.43	3.41	0.63
250	16	26	3–1¼″ x 3¾″	10	18	2–1″x3″	4″	7″	½″	2.78	3.41	0.67
300	16	30	3–1¼″ x 3¾″	10	20	2–1″x3″	4″	6″	½″	3.24	3.41	0.73

Panel 24′ x 24′ between Supports

Safe Live Load in lbs. per sq. ft.	Beam A			Beam B			Floor Slab			Pounds of steel per sq. ft.		Cubic feet of Concrete per sq. ft.
	b	d	Steel	b	d	Steel	t	s	Trus. Con. Bars	T	K	
100	16	20	3–1¼″x3¾″	8	20	2–¾″x2 3/16″	4″	12″	½″	1.62	2.44	0.55
125	16	24	3–1¼″x3¾″	10 8	14 24	2–1″x3″ 2–¾″x2 3/16″	4″	10″	½″	1.94	2.79 2.44	0.57 0.61
150	16	28	3–1¼″x3¾″	10	18	2–1″x3″	4″	8″	½″	2.43	2.79	0.63
175	20	25	4–1¼″x3¾″	10	20	2–1″x3″	4″	7″	½″	2.78	3.36	0.67
200	20	28	4–1¼″x3¾″	10	22	2–1″x3″	4″	6″	½″	3.24	3.36	0.71

Panel 22′ x 22′ between Supports

Safe Live Load in lbs. per sq. ft.	Beam A			Beam B			Floor Slab			Pounds of steel per sq. ft.		Cubic feet of Concrete per sq. ft.
	b	d	Steel	b	d	Steel	t	s	Trus. Con. Bars	T	K	
125	12	28	2–1¼″x3¾″	8	20	2–¾″x2 3/16″	4″	11″	½″	1.77	2.05	0.50
150	16	22	3–1¼″x3¾″	10	14	2–1″x3″	4″	9″	½″	2.16	3.07	0.57
175	16	25	3–1¼″x3¾″	10	16	2–1″x3″	4″	8″	½″	2.43	3.07	0.62
200	16	28	3–1¼″x3¾″	10	18	2–1″x3″	4″	7″	½″	2.78	3.07	0.66
250	20	26	4–1¼″x3¾″	10	22	2–1″x3″	4″	6″	½″	3.24	3.70	0.72

Panel 26′ x 26′ between Supports

Safe Live Load in lbs. per sq. ft.	Beam A			Beam B			Floor Slab			Pounds of steel per sq. ft.		Cubic feet of Concrete per sq. ft.
	b	d	Steel	b	d	Steel	t	s	Trus. Con. Bars	T	K	
75	12	30	2–1¼″x3¾″	8	20	2–¾″x2 3/16″	4″	12″	½″	1.62	1.70	0.56
100	16	26	3–1¼″x3¾″	10	16	2–1″x3″	4″	10″	½″	1.94	2.54	0.58
125	20	24	4–1¼″x3¾″	10	18	2–1″x3″	4″	8″	½″	2.43	3.09	0.62
150	20	27	4–1¼″x3¾″	10	22	2–1″x3″	4″	6″	½″	3.24	3.09	0.67
175	20	31	4–1¼″x3¾″	10	26	2–1″x3″	4″	5″	½″	3.89	3.09	0.73

Figure 30. Tables for Ordering the Kahn System of Reinforced Concrete.

Compared to methods of reinforcement that were likely developed once the patent on the Kahn Bar expired, this lack of interchangeability is all the more obvious. Modern reinforcement consists of standard length bars which a steel stirrup is wrapped around. This method would prove to be even easier and cheaper to use than the Kahn Bar, figure 31. One can theorize that the Trussed Concrete Steel Company backed by the use of their proprietary system would attempt to continue to use the Kahn Bar right up until the patent expired, at which time modern methods of reinforcement would have made the Kahn Bar obsolete. Writings from the British division of the Trussed Concrete Steel Company state that “by 1930, the Kahn Trussed Bar was little used in the company’s general designs. It survived a little longer in the Truscon Insitu Floor (the Kahn System) and finally was sold only for the manufacture of lintels, specified by architects who had learned to rely upon the results obtained. But there was difficulty in getting the Bar rolled in small quantities and finally, in 1936, production ceased” (TRUSCON: The First Fifty Years).

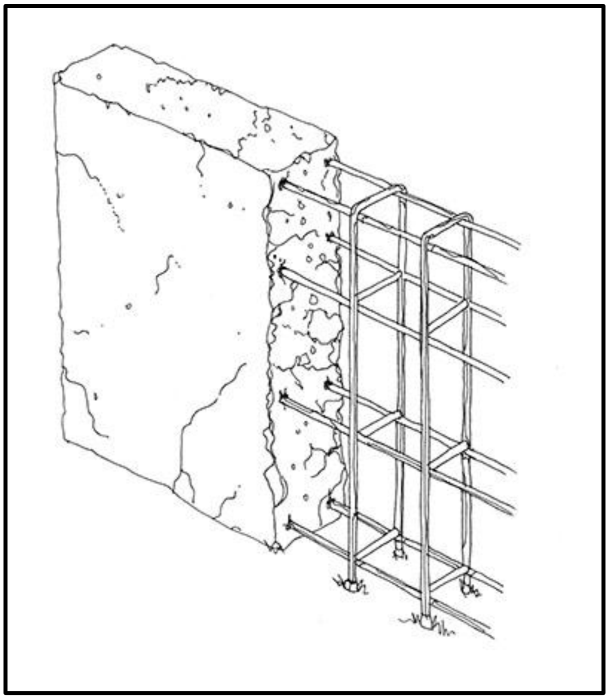


Figure 31. Modern Concrete Reinforcement.

Finally with the Truscon Company's flagship product being rendered obsolete, the marketing strategy dictated a merger. Around 1937 the Truscon Company and a number of smaller steel companies were purchased by the Republic Iron and Steel Company (Republic Steel Corporation Audiovisual Collection). To reflect the merger the Republic Iron and Steel Company shortened their name to The Republic Steel Company. They were now the third largest steel company in the world. This merger effectively ends available research into the Truscon Company as any research would need to be directed at the Republic Steel Company as a whole. It also should be noted here that the American involvement in the English and Japanese divisions of the Trussed Concrete Steel Company effectively ended around 1919 " (TRUSCON: The First Fifty Years). At this time English and Japanese shareholders bought the entire American held shares in both countries respectively. This made both foreign divisions of the Trussed Concrete Steel Company entirely separate companies from their American counterpart.

Soon after the buyout of Truscon by the Republic Steel Company what remained of the company also vanished. In 1942 both Albert and Julius Kahn died. Hereby ended the lives and careers of the two brothers responsible for pioneering the architecture and engineering of industrial architecture.

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