# Pennsylvania Convention Center

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**Henry CLARK**
President
Ross Bryan Assoc.
Nashville, TN, USA

Henry Clark, born in 1944, received his engineering degree from Vanderbilt University. He has worked in this firm for 25 years, and the firm has a wide ranging consulting practice, involved in major projects across the United States.

**SUMMARY**

The Pennsylvania Convention Center in Philadelphia is currently under construction. The design of this structure is reviewed along with construction techniques. The Center includes the renovation and adaptive reuse of the Reading Railroad Terminal which was originally constructed in 1893 as a riveted wrought iron structure. The Center has a surface area of approximately 115 000 m$^2$, one-tenth of which is renovation and the remainder is new construction. New construction is long span and executed in concrete and structural steel.

**RÉSUMÉ**

Le Palais des congrès de Pennsylvanie est en cours de construction à Philadelphie. L'article examine la conception de cet ouvrage ainsi que les techniques de construction utilisées. Cette réalisation comporte la rénovation et la réutilisation en grande halle de l'ancienne gare tête de ligne du Reading-Railroad, dont la charpente en fer forgé et riveté fut construite en 1893. Le palais couvre une surface totale de 115 000 m$^2$, dont un dixième environ représente la partie rénovée et le reste la partie nouvellement construite. Cette dernière est réalisée en éléments d'acier et de béton structuraux de grande portée.

**ZUSAMMENFASSUNG**

Das Pennsylvania Convention Center (Staatliches Messezentrum) in Philadelphia ist zur Zeit im Bau. Der Entwurf dieses Gebäudes ist hier mit seiner Bautechnik zusammen besprochen. Dieses Projekt beinhaltet die Renovierung und Anpassung der Bahnsteighalle des ehemaligen Reading-Railroad-Kopfbahnhofs auf, die im Jahre 1893 aus vernietetem Schmiedeisen gebaut wurde. Um die Halle herum entsteht ein neunmal grösserer Neubau als Beton- und Stahlkonstruktion grosser Spannweite.

# 1. DESCRIPTION OF PROJECT

## 1.1 Development of Concept

The City of Philadelphia and the State of Pennsylvania combined resources for a convention center development in Philadelphia. A stimulus to the city and state economy was sought, and due to the rising demand for convention sites, a convention center was selected as the development project. A request for proposal was sent out to interested development groups asking for proposals and sites.

## 1.2 Selection of Team and Site

Based on proposals submitted, a team and site were selected in 1984. The team included a development group that owned the downtown historical site. Other members of the team included the construction group and architectural and engineering companies.

The site is east of City Hall at the Reading Railroad Terminal on Market Street at 12th Street. The Terminal, which opened in 1893, was to be renovated and connected across Arch Street to the north to a new Convention Hall covering four blocks between Arch and Race Streets from 11th to 13th Streets. When constructed, the Terminal was the longest three-hinged arch structure of the time.

## 1.3 Project Development

Originally, the project was to be developed by private companies and leased to the City. This was revised to control by a Convention Authority which was set up by the City and State. Construction was initially to be done in a construction management format with segments of the work designed and released as contract packages. After early releases of the concrete caissons and street removal packages, the project was revised to two single contracts, one for the new Convention Hall and one for the renovation of the Reading Terminal Shed. Despite the changes, the new Convention Hall bid at $129,900,000.00 in December, 1990, which was within 1% of budget.

After selection of the team and site in 1984, the Pennsylvania Convention Center Authority was established. The acquisition of property, the relocation of existing businesses, and the demolition of buildings were begun.

# 2. HISTORY OF SITE

## 2.1 Philadelphia and Reading Railroad Terminal

In the 1880's, the Philadelphia and Reading Railroad set out to consolidate train traffic in downtown Philadelphia. A site along Market Street was chosen three blocks east of the city center. The site at Market Street had two important market houses for fresh foods which were to be incorporated into the Terminal structure. The markets remained open during construction as their new space was built to the north which allowed them to move and reopen immediately before their facilities were torn down. This same concept will be followed 100 years later, as the current Market tenants will operate as the Shed is renovated.

Trains were elevated on viaducts in the city, which required the terminal floor to be over the new Market space some 7.5 meters above street level. Thirteen tracks were planned in the Terminal with passenger platforms between them. The Terminal Shed roof is a three-hinged arch constructed of riveted wrought iron. Twin arch trusses are spaced at 15.3 meters apart and span 79.2 meters from

center to center of base pins. The center pin of the arches is 27 meters above the base pins. The arch bases are tied together with wrought iron eye bars as tension ties.

The Terminal and Head House were designed by the Wilson Brothers and Company. Analysis of the Terminal roof was done graphically and the original drawings remain. Analysis was done for the following load combinations.

- First: Snow on one side and dead load
- Second: Snow on both sides and dead load
- Third Wind on one side and dead load
- Fourth: Snow and wind on one side, snow only on other side and dead load

Snow loading was assumed at 12 psf with wind pressure taken to be 35 psf against a vertical surface.

Mr. Joseph M. Wilson presented a paper describing the design of the Terminal and Head House to the 1895 annual convention of the American Society of Civil Engineers. The original ink on linen drawings of the buildings were retained by the railroad in the Head House until 1985 when they were given to the Athenaeum, a historical respository in Philadelphia. These drawings have been invaluable in the design of the Terminal Renovation.

### 2.1 Adjoining Convention Hall Site

The city center of Philadelphia has had significant commercial development for over two hundred years. Hence, the four blocks for the Convention Hall had the potential for various foundation structures to be present. Fortunately, historical documents of various site utilizations minimized problems. An engineered earth fill 1.22 meters thick was placed over the rubble fill which is in place for much of the site. This provided a leveling of the site and a bridge over localized soft spots. Drilled concrete caissons were utilized to carry building loads to the underlying rock.

## 3. PROJECT DESIGN

### 3.1 Convention Hall Design

The Reading Terminal was to be used for ballroom, meeting and assembly functions. The Convention Hall was designed to have 30,000 square meters of display space for large conventions and trade shows. The two facilities are tied together with a three-story building bridge across Arch Street.

The Convention Hall was placed on the second floor in a similar fashion to the original train layout to the Terminal. This allows for a one level connection between the Exhibit Hall and the Terminal facilities. The ground floor of the Hall has parking, administrative, kitchen, and meeting spaces.

Numerous layouts were studied for the Convention Hall, and the final design was to use a 18.3 x 18.3 meter column spacing on grade and a 36.6 x 36.6 meter column spacing from the second floor to the roof. The second floor is framed with concrete, and the roof utilizes a steel truss system. The Hall construction closed Cherry Street running east-west but bridged over 12th Street to allow this north-south artery to remain with its vehicular and trolley service.

The Convention Hall is supplied by trucks which utilize a ramp to approach from the north. This ramp follows the plan of the original train viaduct. The trucks arrive on an apron structure which allows movement east and west to various

portions of the Hall, and three ramps allow access into the Hall for delivery or pickup of displays. The truck apron is designed to carry highway loading, so fully loaded trucks can drive directly from the highway across the apron into the Convention Hall.

Along the southern edge of the Hall is a Concourse to allow pedestrian entrance and distribution to the Hall level from the street level. Access to the site is available by commuter train under the Terminal, by automobile, or by electric trolley that passes beneath the Hall on 12th Street.

## 3.2 Selection of Structural Systems

Design loads for the Hall, Apron, and Concourse are as follows.

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| Convention Hall | 1709 kg/sq. meter |
| Apron | AASHTO HS: 20 |
| Concourse | 488 kg/sq. meter |

The heavy Hall loading is the result of larger shows of heavy equipment and the developing practice of double or triple stacking in exhibits to lower exhibit floor space costs. This heavy loading allows trucks to move into the display space to unload and this also allowed construction of the Convention Hall roof off of the elevated floor.

A number of structural systems were studied for the Hall floor including structural steel and concrete. A conventionally reinforced beam and girder concrete system was chosen. The floor slab is 20.3 cm thick and spans between the 80.5 x 147 cm deep beams. The beams are carried by girders 1.52 meters by 1.8 meters deep at the columns and 1.5 meters deep through midspan.

Ducts are placed in the beams and girders between floor boxes to provide distribution of water, electrical power, and compressed air to convention exhibitors. Floor boxes are placed on four sides of each column that extends to the roof and at a 9.2 x 9.2 meter grid between. The design drawings detailed reinforcing placement in the girders at columns to provide space for the floor boxes.

During construction, the general contractor requested permission to cast the girders up to the bottom of the floor boxes and below the top steel first. The beams were part of a secondary cast that included the slab and the tops of the girders. The contractor chose a moveable formwork system for casting of a bay of beams. By staging the form removal on the girders and placing reshores as form segments were removed, we were able to accommodate the contractor's request. Bottom and side bars for the beams were doweled out of the sides of the girders to lap with the beam steel.

The Hall floor and roof span over 12th Street, which remained from previous street layouts. This provides for a continuous Convention Hall over 256 meters in length from east to west.

The Convention Hall roof with a 36.6 x 36.6 meter grid was designed with 1.5 meter deep trusses spanning to a pair of bowstring steel trusses. The transverse trusses follow the shape of the top chord of the bowstring trusses. This develops a shape similar to the Reading Terminal and provides for large open areas in the Hall.

The bowstring shaped main roof trusses reach a maximum depth of 7 meters which precludes their transportation over the road from a fabrication plant to the site. The trusses were designed in prefabricated sections to be assembled at the

site on the Convention Hall floor. The floor capacity allows for this fabrication and loads imposed by cranes erecting the completed trusses. The trusses were set in pairs along a 36.6 meter column line. A bow tie section over the column and extending 4.6 meters into each span was prefabricated and erected on the column. The top and bottom chords of the 27.4 meter remainder of the trusses were prefabricated together with their horizontal truss elements. These sections are shipped to the site, then welded together with diagonals and verticals to form the main truss section. This center section is then lifted and erected to the bow tie section over the columns. This technique was followed in construction as anticipated in design.

The truck apron utilizes structural steel and a composite concrete slab upon which a waterproofing membrane and a concrete wearing slab are placed. This area is separated by an east-west expansion joint from the Hall, although it is supported by the Hall structure using sliding bearings. The apron progressed as the Hall was started and was used to distribute material to the Hall construction. The support of the Apron on the hall girder provides a cantilever moment which balances loading and moments on the exterior column from the Hall itself.

The Concourse is framed in concrete and is separated from the Hall with an expansion joint. That location to the Concourse is supported on the Hall framing using sliding bearings.

Due to the heavy column loads of the Convention Hall, a deep foundation system was required to bear on rock. Concrete caissons were selected. Caissons ranged from 9 to 32 meters in length and from 1.22 to 1.83 meters in diameter. Bearing of caissons was enhanced by either socketing into rock or belling the shafts out to enlarge the base. Bearing pressure was 5.74 MPa on approved rock strata.

### 3.3 Investigation of Reading Terminal

Contamination with toxic materials proved to be a problem with the Terminal. PCBs were present from the train brake fluid which leaked into the track areas inside the Terminal and in the Viaduct areas. Complete removal of the PCBs was required before the Terminal could be completely investigated. This removal slowed the transfer of the property and subsequent construction. Additionally, leaded paint was present on the wrought iron in the Terminal, which eliminated sandblasting as a cleaning procedure due to costs. Asbestos was present in the roofing, which slowed its removal and increased costs as well.

The Terminal had been maintained for the bulk of its 100-year life by the Reading Railroad. In the last ten years, maintenance had decreased and deterioration had begun to accelerate. As the roofing and the sheathing came apart, water increasingly gained access through the roof. The Terminal floor framing is very heavy since it was designed for train loads; therefore, most sections retain sufficient residual capacity for existing and new loading.

Columns were a primary concern because of load-carrying capacity and the fact that section loss is present at the Market floor and the Terminal level. A concrete encasement to supplement capacity was developed for the basement level. Preserving the historical appearance of this landmark structure required the column to remain as close to its original shape through the Market. To provide for fire resistance, the column will be painted with intumescent paint, and four sprinkler heads will be provided to flood each column in case of fire.

The roof arches have various levels of deterioration which become more prominent toward the north end, which is open. Repairs which Reading Railroad has made over the years have been made by welding in new sections of plate or angle as

required to replace the deteriorated section. Generally, considering the age of the roof, the trusses were in good condition. The tension tie elements have varying stages of section loss due to rusting. A secondary system of tie rods will be added to assure the integrity of the arches.

The trusses have one fixed bearing and one expansion bearing. The expansion bearings have various levels of corrosion and appear to be frozen. Bases will be lifted and a sliding bearing will be placed at the expansion side.

The roof trusses and structure have three east-west expansion joints which will be maintained during the renovation. The track floor has numerous expansion joints which will not be required as the structure will be enclosed by the renovation. Floor joints that line up with the roof joints will remain, while the remainder will not.

### 3.4 Design of Terminal Renovation & Expansion

Floor members in the track floor which have lost section beyond capacity will be removed and replaced before the new concrete slab is placed. The track stringers are lower than the platform sections, so knee wall frames of angles will be used to create a bearing for the new floor slab metal deck.

Two new levels of framing are being added to sections at the north end. Those areas are steel framed with semi-lightweight concrete slabs to minimize dead load impact to the existing structure of the Shed. The larger level is the Ballroom floor while the remaining areas are used for mechanical service and other support functions.

The renovation and new construction will be done in three phases as Market tenants are moved out of a section into temporary quarters on the south side of Filbert Street. This will continue the tradition of keeping the Market open as the original builders did 100 years ago. Repair of columns and Market framing will be performed while tenants are out of their respective spaces. Care is being taken to preserve the look of the Market and its historical significance. The Market will be refurbished and ready for its second 100 years of service to the Philadelphia community as well as to visitors from around the world.

## REFERENCES

1. WILSON, JOSEPH M.: The Philadelphia and Reading Terminal Railroad and Station in Philadelphia, ASCE Transactions 757, August, 1895.