The Great Exhibition Building and its Design

Before finding its permanent ‘home’ in Sydenham, and vanishing forever in the flames of the 1936 fire, the history of the Crystal Palace building began elsewhere, with a controversial birth at the heart of Victorian Britain’s social and political life. The relocation of the Crystal Palace to Sydenham is in fact deeply connected to story of the Great Exhibition of 1851 and of its huge success.

In 1850 the Royal Commission for carrying out the Great Exhibition scheme was unveiled. Amongst the Commission’s first tasks were: identifying a suitable site and choosing a design for the construction of the main exhibition building. The time allowed for the preparation of the drawing was extremely short (only one month) but despite that, 233 designs were submitted. Thirty-eight of the designs were received from abroad, including France, Belgium, Holland, Germany and Naples. The Commission had defined a number of criteria that were of paramount importance in order to attain the desired aims, namely:

"1. Economy of construction.
"2. Facilities for the reception, classification, and display of goods.
"3. Facilities for the circulation of visitors.
"4. Arrangement for grand points of view.
"5. Centralisation of supervision.
"6. Some striking feature to exemplify the present state of the science of construction in this country.

After the designs were received and exhibited in the rooms of the Institution of Civil Engineers, the first problem with the scheme became obvious: there was in fact no prior experience of such events and there was therefore little to no guidance that could be provided to the designers and to the Committee themselves to judge on the most suitable architectural design.

The Great Exhibition building had to showcase products coming from all nations and be suitable to accommodate a wide range of needs, a titanic mission compared to more modest pursuits of other Exhibitions where individual countries displayed their items in much smaller buildings/pavilions.

Of course the most obvious course of action was to compare the designs to those of buildings that were first erected for similar purposes; particularly temporary structures such as those erected in Paris for the periodical Industrial Expositions in 1849 and the Knoll Wintergarden in Berlin.

Following the approval of a general design for the building by the Royal Commission, Charles Heard Wild, as engineer, and Owen Jones, as architect, were appointed to co-operate with Digby Wyatt (already secretary to the Executive Committee) in carrying out the project.

Once published, the design of the Building Committee met with anything but public approval; some of the critics called into question the practicability of the execution of the enormous dome that was at the core of the design; others complained that the outlay would be unnecessarily big for a temporary exhibition, and expressed their fears that the structure would be too expensive and –therefore– unlikely to be dismantled following the Exhibition. However the objection which had most weight with the general public was the enormous amount of brick
construction that would not only require longer for its erection but that would undoubtedly cause serious damage to the identified site of Hyde Park and the surrounding neighbourhood. The matter caused so much public concern that petitions were presented to the Houses of Parliament in opposition to the Hyde Park site, forcing the Building Committee to explain the reasons behind their decision.


If the design procedure allowed only for a month time, equally tight was the schedule that the contractors had been obliged to respect for the submission of their tenders. It was at that stage that Fox, Henderson and Co. presented a tender upon a completely different design, which although resembling the Committee’s in terms of the general plan’s arrangement, was markedly different in terms of construction and appearance. The design was by Mr Joseph Paxton and was to become the Crystal Palace building as we now know it, with the exception of the transept and the semi-circular roof which were further added upon suggestion by Sir Charles Barry.

The Royal Commission was instantly impressed with Paxton’s design and its ingenious use of materials other than solid bricks, also resulting in much lower construction costs. Paxton’s design was not entirely new to the public as he had in fact published it on the Illustrated News before its official approval, believing its best shot at receiving favourable reception from the Commission was to gain public endorsement beforehand. The favourable opinion of the public had in fact given him the confidence to procure a tender for the execution of the work and the contract with Fox, Henderson and Co. was swiftly signed.

The building was not an entirely fresh project for Paxton either. Though he had never attempted the design in such grand scale, he himself had stated that he could not have produced the design for a building of such magnitude in such a short time without the benefit of his previous experience in constructing similar structures. In a lecture he delivered at the Society of Arts on the 13th of November 1850, Paxton himself highlighted the relevance of his previous experiences and recalled his work at Chatsworth:

“The Great Industrial Building (...) Its peculiar construction, in cast-iron and glass, together with the manner of forming the vast roof, is the result of much experience in the erection of buildings of a similar kind, although on a smaller scale, which has gradually developed itself through a series of years (...) In 1828, when I first turned my attention to the building and improvement of glass structures, the various forcing-houses at Chatsworth, as at other places, were formed of coarse thick glass and heavy woodwork, which rendered the roofs dark and gloomy, and, on this account, very ill suited for the purposes they were intended to answer. My first object was to remove this evil, and, in order to accomplish it, I lightened the rafters and sash-bars, by bevelling off their sides (...) The most appropriate manner to form and support level glass roofs, to a great extent, was that adopted this year for the New Victoria House at Chatsworth, which may be considered a miniature type of the Great Industrial Building.”
Thanks to his work at Chatsworth, Paxton had learned of the great disadvantages and unsuitability of the common mode of glazing roofs to maximise and channel sunlight into the building. Having learnt from experience, he devised a new roofing system by “ridge and furrows” and calculated precisely how to obtain an economical, low-maintenance and efficient construction.

Following the removal of heavy duties on glass by Sir Robert Peel (for which Paxton was eternally grateful) he could finally explore and expand the use of the material in its designs and he started to focus on the use of flat ridge-and-furrow roofs for extensive structures. Paxton’s desire to bring about innovative building techniques led him to devise a sash-bar machine which allowed for cost-effective and fast erection of glass buildings and awarded him a medal from the Society of Arts in 1841.

His determination to pursue his architectural ambitions also drove him to personally witness the production of new glass sheets at Chance and Co. in Birmingham, and persuade the manufacturers to expand the length of the panes by one extra foot. These accomplishments, borne out of Paxton’s inventiveness and perseverance, were instrumental in the creation of a construction which would have been otherwise unattainable.
The Crystal Palace at Hyde Park

Despite the controversies and complexities related to the construction, and the very limited timeframe to erect the building, on the 1st of May 1951 the Exhibition was opened in Hyde Park by Queen Victoria and Prince Albert and remained open until the 15th of October of the same year.

For the construction of the Great Exhibition building, the glass-maker supplied nine hundred thousand square feet of glass (weighing more than four hundred tons), in separate panes of forty-nine inches each, the largest ever made of sheet glass. The iron master cast three thousand three hundred iron columns, varying from fourteen and a half feet to twenty feet in length: thirty-four miles of guttering-tube, to join every individual column together under the ground; two thousand two hundred and twenty-four girders; and eleven hundred and twenty-eight bearers for supporting galleries. The carpenter undertook the preparation of 205 miles of sash-bar, flooring for an area of thirty-three million cubic feet as well as enormous quantities of wooden walling, Louvre-work, and partition.

A main avenue, 72 feet wide and 66 feet high, occupied the centre through the whole length of the building. Flanking this on either side were smaller avenues 24 feet and 48 feet wide. A row of large trees was enclosed within the building so that a transept of the same width of the main avenue and 108 feet high was included in the design. The total area amounted to 772,784 square feet, or about 19 acres, making the building about four times the size of St. Peter’s at Rome, and more than six times that of St. Paul’s in London. Paxton avoided in any possible way large and solid masses, trying to convey an idea of lightness.

To facilitate ticketing operations and in order to bring down the number of staff in charge, the building had only three entrances but fifteen exit doors. Each avenue was formed by hollow cast-iron columns, which rose in one-19 feet high- first floor and two -9 feet high- upper floors to support the roof. Between the different lengths of the columns “connecting-pieces” were introduced to support girders (in both cast and wrought iron) in horizontal tiers, preserved throughout the whole of the building. While girders on the upper tier supported the roof, those on the second tier only served the purpose to reinforce the columns.

One of the undoubted masterpieces realised by Paxton was his flat ridge and furrows roof. Flat in its general form, it was made up by a series of slight rise and falls in the transverse direction of the building, spanned by light beams or rafters, hollowed out in a groove on the top to form a gutter.
What is to become of the Crystal Palace?

The huge success of the Great Exhibition was inextricably linked to the popularity of the building. The Crystal Palace certainly fulfilled the brief from the Royal Commission: it was much less costly than a standard brick building, it enabled an unprecedented display of products from across the globe, it created a pleasing environment for visitors and last but not least, it stood as the finest example of British might, an aim at the core of the entire Great Exhibition’s scheme. Like most iconic buildings, the Palace did not just respond to functional needs and building requirements but conveyed a clear message. Victorian commentators liked to define it as a fine example of “English modern style”, it exemplified modernity as it put to use the most advanced production techniques and materials of the time and in doing so it also served a symbolic purpose: to represent in its magnitude both the scientific progress of the industrial age and the supremacy of the British Empire.

But even to contemporary standards the Crystal Palace can be defined as an exquisitely modern building: it was modular, each of its component being easily replicated and assembled individually in situ, it was also temporary, being easily assembled and disassembled, and it was therefore what we would call today a low-cost easy-maintenance construction.

It is maybe ironic that its “transient” nature, that of a building meant to be temporary, awarded it much praise and somehow shifted the public sentiment against his destruction, leading instead to its permanent relocation to Sydenham.

*The present structure is capable of enduring longer than the oldest marble or stone architectural monuments of antiquity. The iron, which forms its skeleton or framework, becomes when painted, the most indestructible of materials, and the entire covering of glass may be renewed again and again without in any way interfering with the construction which it covers.*

The Palace was not without detractors; John Ruskin amongst others had published his harsh views against what he saw as a “magnified conservatory”. The public however loved it, and even some early critics of it changed their minds eventually. The removal of the building occupied much public attention by the end of 1851 and the loss of the building was vastly perceived as a threat.

A pamphlet published under the pseudonym of “Denarius” plead against the building’s demolition based on ‘health grounds’; it argued that Paxton’s Palace could be a remedy against pollution and urban misery and that it should be transformed into a public space beneficial to the masses who suffered from London’s general “unhealthiness”.

On similar grounds, Paxton himself had vigorously advocated the transformation of the Great Exhibition building into “a large National place of recreation and instruction”

*The Building, I would suggest, should be allowed to remain standing on account of its peculiar fitness to supply a great public want, which London, with its two and a half millions of inhabitants, stands most essentially in need of — namely, a Winter Park and Garden under glass. At present England furnishes no such place of public resort, for although Kew has a splendid Palm-house, where daily are congregated a great number of individuals, yet its warm and humid atmosphere is only calculated to admit of visitors taking a hasty view of the wonders of the tropics(...) On the contrary, in the Winter Park and Garden I propose, climate would be the principal thing studied, all the furnishing and fitting up would have special reference to that end, so that the pleasures found in it, would be of a character which all who visit could share; here would be supplied the climate of Southern Italy, where multitudes might ride, walk, or recline amidst groves of fragrant trees, and here they might leisurely examine the works of Nature and Art, regardless of the biting east winds or the drifting snow.*

Despite the public’s engagement and the appointment of a special commission to report on possible alternative uses of the structure, the Government was determined not to interfere with the building -which was still property of Fox, Henderson and Co.- and it was decided that the terms of the original covenant should be respected and the Palace dismantled. It was then that a group of private investors – J. Leech, F. Fuller, T. Farquhar, L. Schuster and S. Laing- took an active interest in purchasing the building and having joined forces with a few others, proceeded to acquire it in May 1852. The new proprietors had a clear plan in mind: the building would be rebuilt in Sydenham, where it could be conveniently connected through the Brighton Line Railway of whom Schuster was already Director. The Crystal Palace would rise again enhanced in grandeur and beauty, to become “a Palace for the multitude”.

*Illustration by J. Gilbert in The Crystal Palace that Fox Built*
Palace of the People

As much as becoming symbols of a given social or political age, another prominent quality of successful architectural designs is in that they can transcend the commissioner’s purpose and withstand change. This ought to have been the case of the Crystal Palace, which with its move to Sydenham turned from a gigantic expo pavilion and a symbol of Victorian Britain into that national place of recreation and instruction that Paxton had so strongly wanted: The Palace of the People.

On the 5th of August 1852 a procession bearing a big white banner walked to the site where the first column of the new Crystal Palace was to be re-built. The banner read “Success to the Palace of the People” and it was held by the very workmen who were to erect it.

Predictably, after the constitution of the Crystal Palace Company, Joseph Paxton was offered the role of Chief Director of the Winter Garden, Park and Conservatory while Owen Jones, Digby Wyatt and Charles Wild were invited to assist as Directors of the Fine Art Department, and chief engineer respectively.

All the materials used for the Great Exhibition Building except the glass roof and the framing of the transept were used to rebuild the Palace.

Whilst the two buildings were constructed following the exact same principles, they were decidedly different in terms of design, for reasons of both opportunity and necessity. The sloping nature of the ground and the different purpose which the building was to serve equally influenced the changes made to the original design.

The site chosen for the re-erection of the Crystal Palace was an irregular parallelogram of 300 acres, extending from the Brighton Railway between the Sydenham and the Anerley stations, to the road which borders the top of Dulwich wood. The fall from this point to the railway was 200 feet. It was instantly decided that the best position for the new building would be on the summit of the hill, placed in this commanding position the Palace was in fact visible from both London and the countryside.

Paxton turned the declining nature of the terrain from an obstacle into a positive advantage, using the rapid fall of the ground to create an additional story and so remedying to what was considered a defect of the original building, its lack of elevation. The lower level of the building accommodated the machinery and the Paxton Tunnel (a brick shaft that extended through the entire length of the building), contained the heating apparatus and was connected directly to the railway keeping the ground floor clear from day to day operations.


The building process was fraught with tragedy, as wind and bad weather caused the fall of one of the scaffolds, causing the loss of 15 lives in September 1853. From then on, new scaffolding was erected from the ground instead of being suspended as it had been before the tragedy, slowing down the progress on site by over 3 months.

During the same year, the Crystal Palace Company issued a detailed report of the progress\(^\text{5}\) of the overall project, intending to bring to the public attention the forthcoming opening.
The changes that the structure was to undergo were considerable and even The Times gave a detailed account of the Palace's transformation in August 1853:

It will be remembered that the first design submitted to the Royal Commission by Sir Joseph Paxton was a building in three steps, consisting of a nave and four side aisles, straight from end to end. But, in order to meet the requirements of the Building Committee, a transept was added in the centre; and when it was decided that the large tree should be preserved and enclosed within the building, this transept was moved eastward, thus dividing the building unequally; and, for the purpose of covering the trees, an arched roof, similar to the Chatsworth conservatory, was placed on the top of it. It was suggested by Sir Charles Barry to continue this arched roof over the nave of the building, but the idea was abandoned, owing to the expense, and the fear that the difficulties of construction might possibly delay the opening of the Exhibition beyond the 1st May, 1851. It was felt universally that this feature was wanting to render the Crystal Palace in Hyde Park a perfect building, and it was one of the earliest decisions of the Crystal Palace Company, that the new building should have a circular roof to the nave.

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<th>CRYSTAL PALACE AT SYDENHAM.</th>
<th>EXHIBITION BUILDING IN HYDE PARK.</th>
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<td>Height of centre transept from ground-floor</td>
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The new location also meant that what was originally the side of the building in Hyde Park, became the front of the building in Sydenham. The original structure had to be shortened but its height increased; a transept was placed at each end and one right in the middle, the latter including the big circular roof rising 240 feet over the nave. Another addition to the original design was the introduction of arched recesses at the end of the transepts, each 24 feet deep. The building consisted in total, of a basement floor, a grand central nave, two side aisles, two main galleries - 24 and 8 feet wide respectively- connected by eight spiral staircases, three transepts, and two wings.
The building above the basement was made entirely of iron and glass, with the exception of a portion at the west front, which was panelled with wood. The whole length of the main building was 1608 feet, which with the wings and colonnade leading from the railway station, gave a total length of nearly three-quarters of a mile of ground covered with a transparent roof of glass.

Amongst the features which Paxton replicated from the Great Exhibition building, was of course its famous ridge and furrow system roof, from which the discharge of the rain-water was obtained through gutters conveying water down inside of the columns and from there to the main drains.

Interiors were 44 feet higher than in Hyde Park and they would have had a very different effect and feel than the originals, which relied on a fairly simple and repetitive set or architectural elements. While the columns and girders were originally all in line, in the Crystal Palace they were spaced much more generously and every 72 feet the columns’ pairs were advanced eight feet into the nave to enhance perspective, and completed by arched girders in wrought iron lattice-work; The advancing columns were then tied together forming pillars in the fashion of gothic cathedrals. “Connectors” between columns and girders were used like in Hyde Park, so that the girders would preserve the perpendicularity of the columns and ensure the lateral stiffness of the edifice. The interiors diverged from the Great Exhibition Building not to satisfy a mere architectural ideal but in order to accommodate a very different set of contents, unlike in the past the interior would in fact be adorned with birds, plants, and trees from all over the world and interspersed with fountains, statues, and other works of art.

The floors were laid in a similar manner as in the previous building and consisted of boarding one inch and a half thick.

Easily operated Louvres (ventilators) in galvanised iron were placed around the upper gallery, the summit of the nave and transepts and around the ground floor to regulate the temperature of the building.

Whilst ventilation/cooling had already been abundantly tested by Paxton in his previous works, heating/warming a building of such magnitude such as the Crystal Palace required a new leap forward. The method of using hot water to heat rooms was not new as it had been tested since the 16th century to heat residential buildings as well as green houses. Introduced in Britain by Bonnemain following examples set in St. Petersburg, it was perfected for use in churches, libraries and other public buildings. Having attracted the interest of Paxton, amongst others, hot water was adopted for the heating system of the Crystal Palace. Despite it being a
relatively ‘simple’ plan, the scale of the building was such that its adaptation demanded in depth planning and consideration; it was in fact to be tested how much water could be effectively conveyed through the pipes through pressure from the boilers. Paxton had indeed tested a hot water apparatus at Chatsworth, however the experiment was on too small a scale for it to be replicated effortlessly in Sydenham, where the hot water pipes would have stretched, if placed in a straight line, to a distance of more than 50 miles.

The system engineered by Paxton and Henderson comprised a set of 22 boiler houses placed under the floor level at certain intervals, each containing two boilers holding 11,000 gallons of water. Two main pipes conveyed water from the boilers through to smaller pipes around the building and back, so that the water could be kept in constant motion throughout by the propulsion of heat.

On the 10th of June 1954 the new Crystal Palace was ready to open to the public. It was completed at a cost of nearly a million and half sterling and it was at the time the largest recreational public space in the world. The official ceremony was attended as it had been in 1851 by Queen Victoria and the Prince Consort. Upon opening the Palace, Victoria expressed her desire that the wonderful structure and the treasures of art and knowledge which it contained may long continue to interest, delight and amuse the minds of all classes of British people. The result was a building so majestic that it prompted Prince Albert to exclaim:

*I feel like a father whose child has come to man’s estate and does not believe the promise of his infancy.*

By 1885 the Company could boast that the Palace had already been visited by 38,271,887 people, 7,000,000 more than the entire population of the UK at the time. Unfortunately though, despite the visitors, the Crystal Palace at Sydenham was never a financially successful enterprise and a number of fires and disasters wrecked different parts of the building in the second half of the 19th Century. The original investors never recouped the money spent on its construction and maintenance and in 1911 it was up for sale by auction again.

Despite the lack of success of the business side, the Crystal Palace however did not only fulfil its mission but exceeded it, by cultivating art and science and making it available to the general public.

Over a hundred years after the tragic fire that erased it from our physical environment, the Crystal Palace it is still a much cherished place in the public’s consciousness. Its history is one of human ingenuity and determination that opened the door to leisure and entertainment for the broader public. The Crystal Palace and its treasures brought the world to a neighbourhood of South London when most could not afford to explore it. From a symbol of Victorian England, it was re-imagined as a most modern place of learning and amusement. Aside from Royalties and the elite that took part in its festivals and celebrations, the Crystal Palace really became a place for the people and it sits at the inception of a modern era where beauty and entertainment are not solely a prerogative of the privileged.

Paxton’s vision was fully accomplished and the enduring success of his building is testament to the power that architecture can have in shaping our lives. The Crystal Palace’s history is ultimately not simply the history of a building but of the people who took part in shaping it, be it in its construction or enjoyment. This is why Paxton’s legacy is still alive despite the building’s destruction and why the Crystal Palace will never cease to intrigue and inspire curiosity and wonder.
2 The Opening of the Crystal Palace considered in some of its Relations to the Prospects of Art, by John Ruskin, published by Smith Elder and Co., 65 Cornhill, 1854, [Book in the public domain]
3 A Medical Man’s Plea for a Winter Garden in Crystal Palace, Van Voorst, London, 1851 [digitalised by the Internet Archive in 2016]
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6 Idem, p. 11.
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