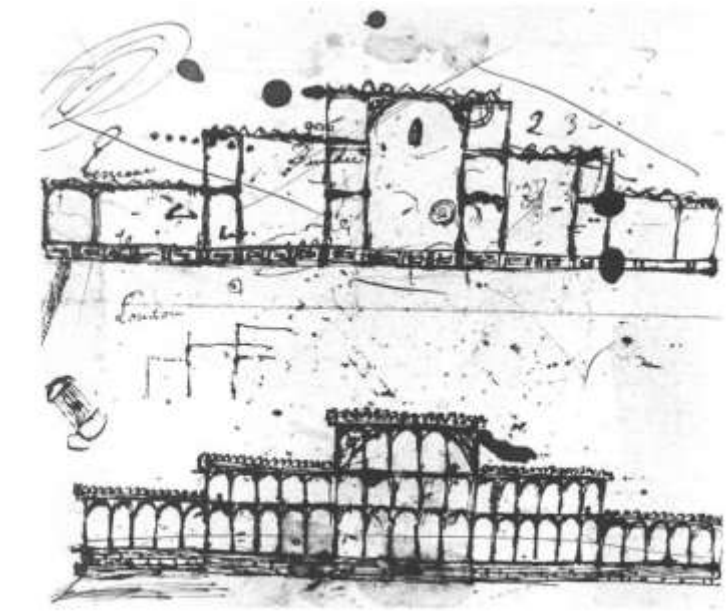
Project Governance & Control, The Building of the Crystal Palace

By Pat Weaver

The Crystal Palace was built in London for the Great Exhibition of 1851. To put this in historical perspective, this is just 35 years after the Battle of Waterloo brought an end to the Napoleonic wars, and 60 years before Henry Gantt began his work.

A Brief Synopsis of the Building

The Crystal Palace was a building the size of a modern shopping mall: 1848 feet [563.3 meters] long, 408 ft [124.4 m] wide and 108 ft [32.9 m] high, with a roofed area of 772,784 square feet [71,794m²] about 19 acres [7 Hectares]. The sketch plans were approved on the 11th June 1850:



Sir Joseph Paxton's original sketch on blotting paper of the Crystal Palace. 11 June 1850.

Fig.1 The famous 'original design'

When the 'design' was approved, tenders were sought from industry and the design proposal from Fox, Henderson and Co accepted. Work started on the 15th July 1850, possession of site was granted on the 30th July, the first column was erected on the 26th September and the formal contract signed on the 31st October. The initial construction in Hyde Park required an existing row of elm trees to be preserved within the structure:

Fig. 2 These main barrel vaults were the only part of the structure made from wood.

The design was highly modular, based on the largest sheet of glass then available measuring 10 inches wide by 49 inches long. And the construction process was highly mechanised with substantial off-site fabrication[1].

Fig. 3 The exhibition in full swing.

[1] For more on the construction see: http://en.wikipedia.org/wiki/The_Crystal_Palace

The Great Exhibition opened on the 1st May 1851, the construction time was 8 ½ months. It was a fantastic success with 2,444,241 public visitors, slightly more than the total population of the city at the time (estimated at 2,350,000).

The name Crystal Palace was created by the general public during the exhibition period and remained associated with the building when it was sold to a private company and moved from its location in Hyde Park to a new site in the South of London. The structure was relocated to a hill in the suburb of Sydenham as a venue for other shows and exhibitions.

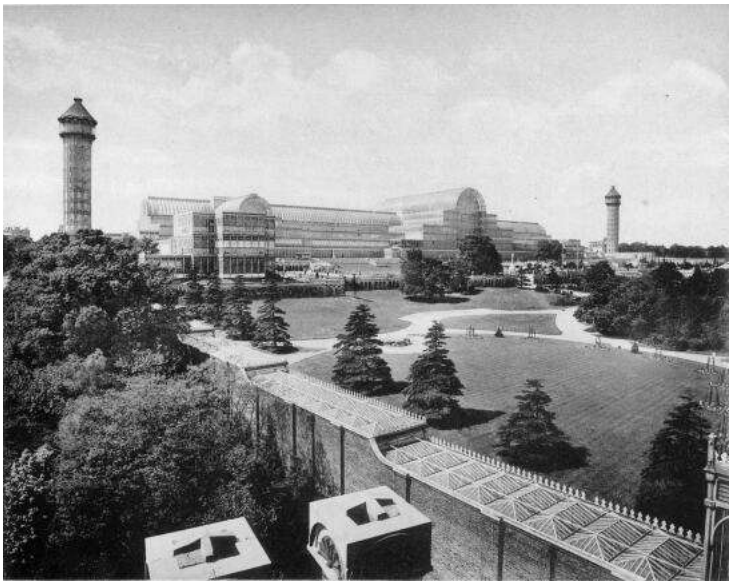


Fig. 4 The rebuilt Crystal Palace in Sydenham (now Crystal Palace)

The building was destroyed by fire on the 5th December 1936 (an event witnessed by my Mother).

Fig. 5 "This is the end of an age" Sir Winston Churchill

To appreciate the significance of this building, the suburb it was located into, the local football club and the parkland that housed the recycled building all retain the name Crystal Palace.

Governing and Controlling the Construction

My interest in this project is very much focused on the project controls and governance aspects of the management of this remarkable endeavour; and during a trip to the UK in mid-2013, I spent an enjoyable, but frustrating day browsing through the reports of the Royal Commission responsible for the whole of the exhibition and its legacy.

The Victoria and Albert Museum holds copies of the five reports of the Royal Commissioners responsible for constructing the exhibition buildings and facilities and staging the Great Exhibition. Reading through them, looking for information on the management of the construction process several aspects stand out. The first is, the first report was not written until after the exhibition finished. And the major disappointment was the fact the construction was contracted to the engineering firm Fox, Henderson and Co, and as a consequence, the actual construction management processes were not documented by the Royal Commissioners.

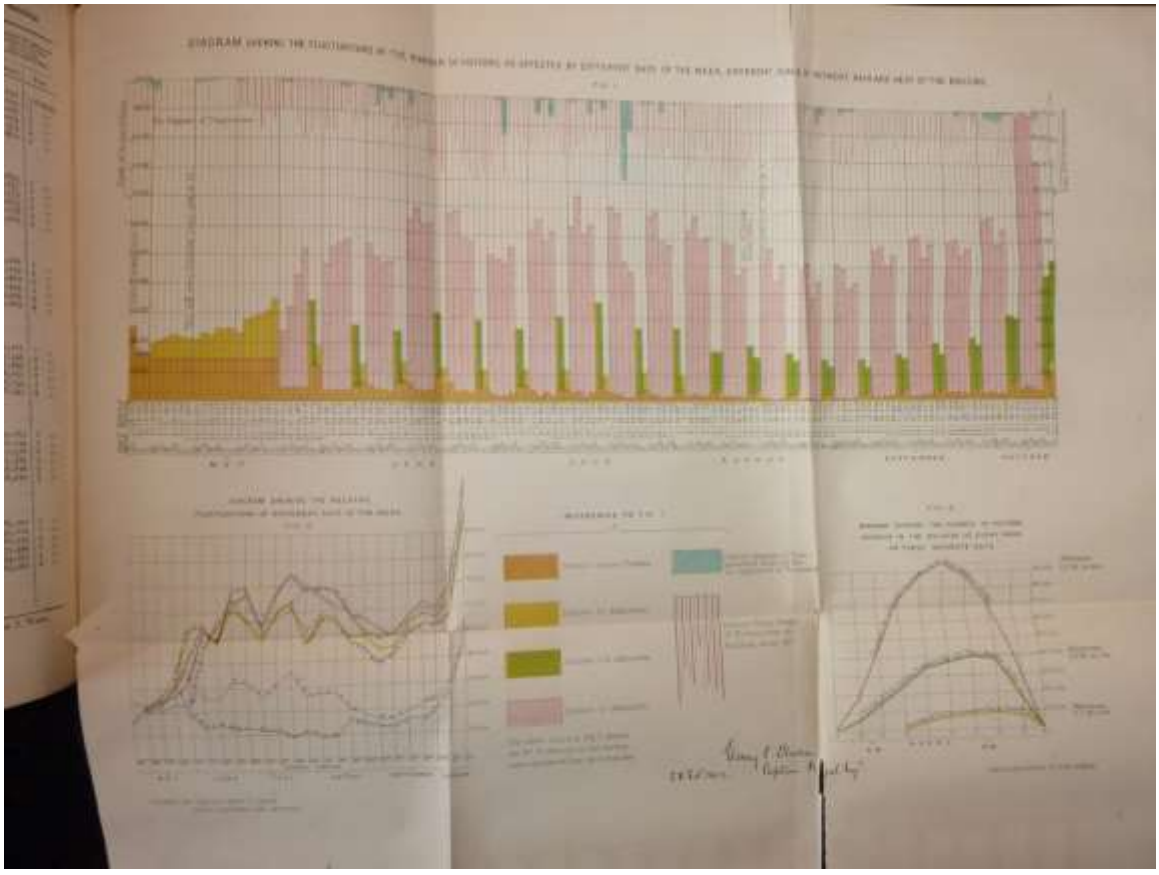


Fig. 6 The very fragile nature of the report prevented a better image being captured.

However, the use of graphical images to convey complex data is apparent, as demonstrated by this high quality chart detailing attendance against a range of daily factors. The chart clearly demonstrates the ideas embedded in William Playfair's *Atlas* of 1801 were understood and in general use (Royal Commissioners are rarely adventurous). The various diagrams include line graphs, histograms and date scales but unfortunately only relate to the period the exhibition was open to the public.

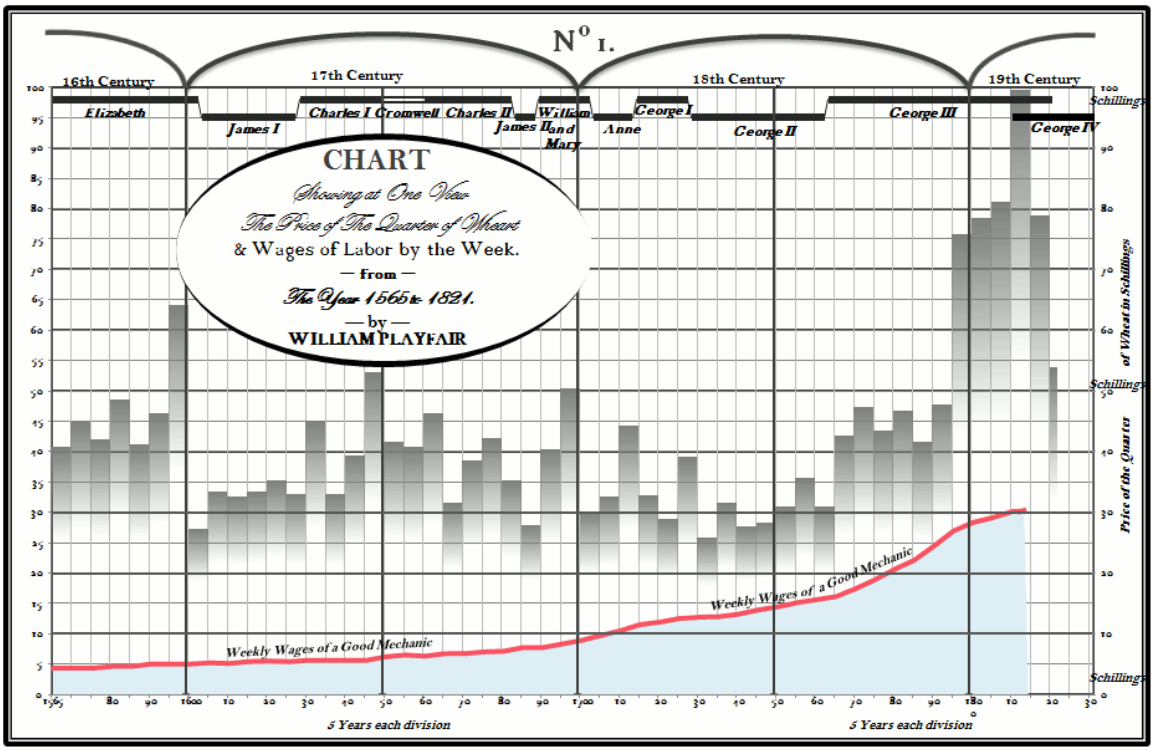
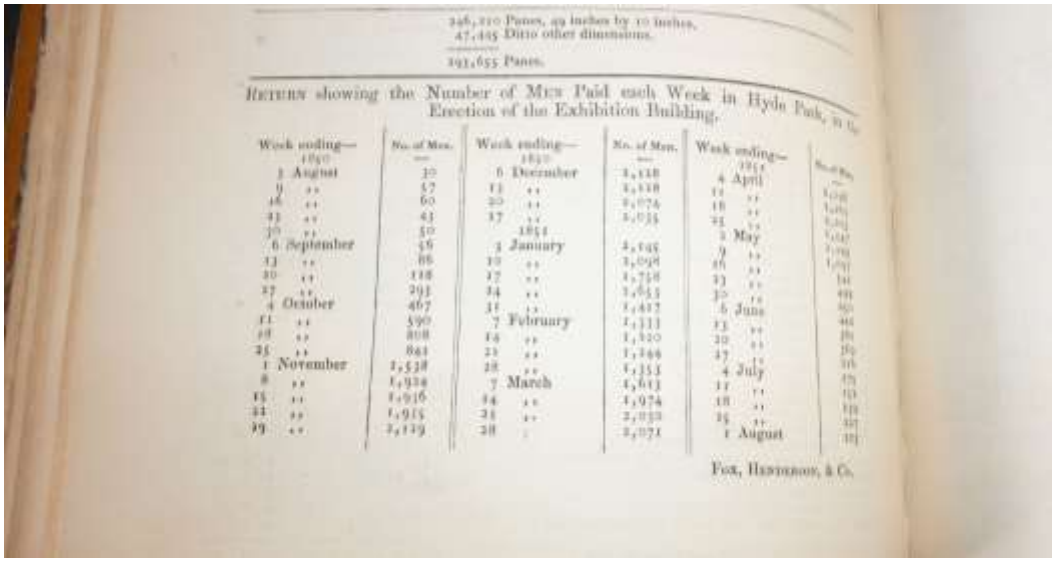


Fig. 7 For comparison, a chart by William Playfair from 1821.

Detailed records of the construction process are also reported by the commissioners. Information on the construction workforce on site indicates sophisticated record keeping, as can be seen from the table below, the workforce on site peaked at 2145, supported by many more off site engaged in the fabrication and transport of the component parts to Hyde Park.



246,210 Panes, 49 inches by 10 inches,
47,445 Ditto other dimensions.

293,655 Panes.

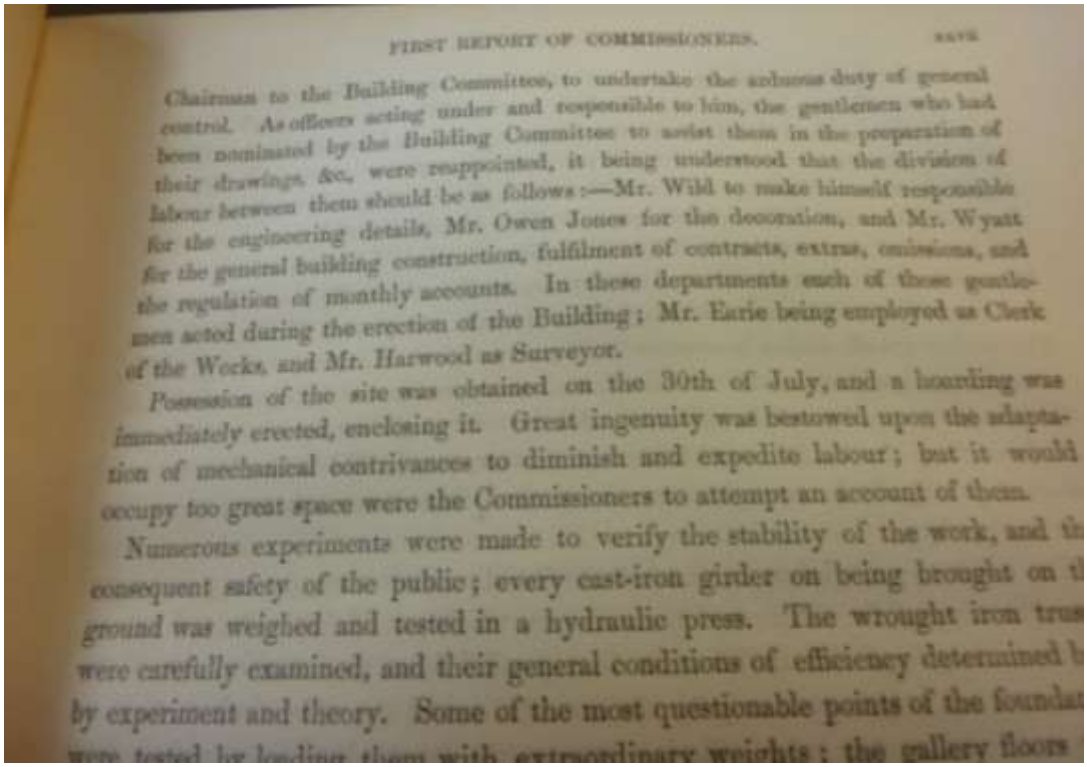
RETURN showing the Number of MEN Paid each Week in Hyde Park, in the Erection of the Exhibition Building.

Week ending—	No. of Men.	Week ending—	No. of Men.	Week ending—	No. of Men.
1850		1850		1851	
3 August	30	6 December	1,118	4 April	
9 ,,	57	13 ,,	1,118	11 ,,	
16 ,,	60	20 ,,	1,074	18 ,,	
23 ,,	43	27 ,,	1,035	25 ,,	
30 ,,	50	1851		1 May	
6 September	56	3 January	1,145	9 ,,	
13 ,,	86	10 ,,	1,098	16 ,,	
20 ,,	118	17 ,,	1,718	23 ,,	
27 ,,	293	24 ,,	1,653	30 ,,	
4 October	467	31 ,,	1,417	6 June	
11 ,,	590	7 February	1,333	13 ,,	
18 ,,	808	14 ,,	1,320	20 ,,	
25 ,,	841	21 ,,	1,269	27 ,,	
1 November	1,538	28 ,,	1,353	4 July	
8 ,,	1,934	7 March	1,613	11 ,,	
15 ,,	1,936	14 ,,	1,974	18 ,,	
22 ,,	1,915	21 ,,	2,033	25 ,,	
29 ,,	2,119	28 ,,	2,071	1 August	

FOX, HENDERSON, & Co.

Fig. 8 Record of the on-site workforce.

Recognising the risks associated with using relatively untried technologies in such a monumental structure, quality control was given a very high priority. Inspectors and superintendents were appointed and quality control processes included stress testing components and load testing foundations implemented.



FIRST REPORT OF COMMISSIONERS. xxvii

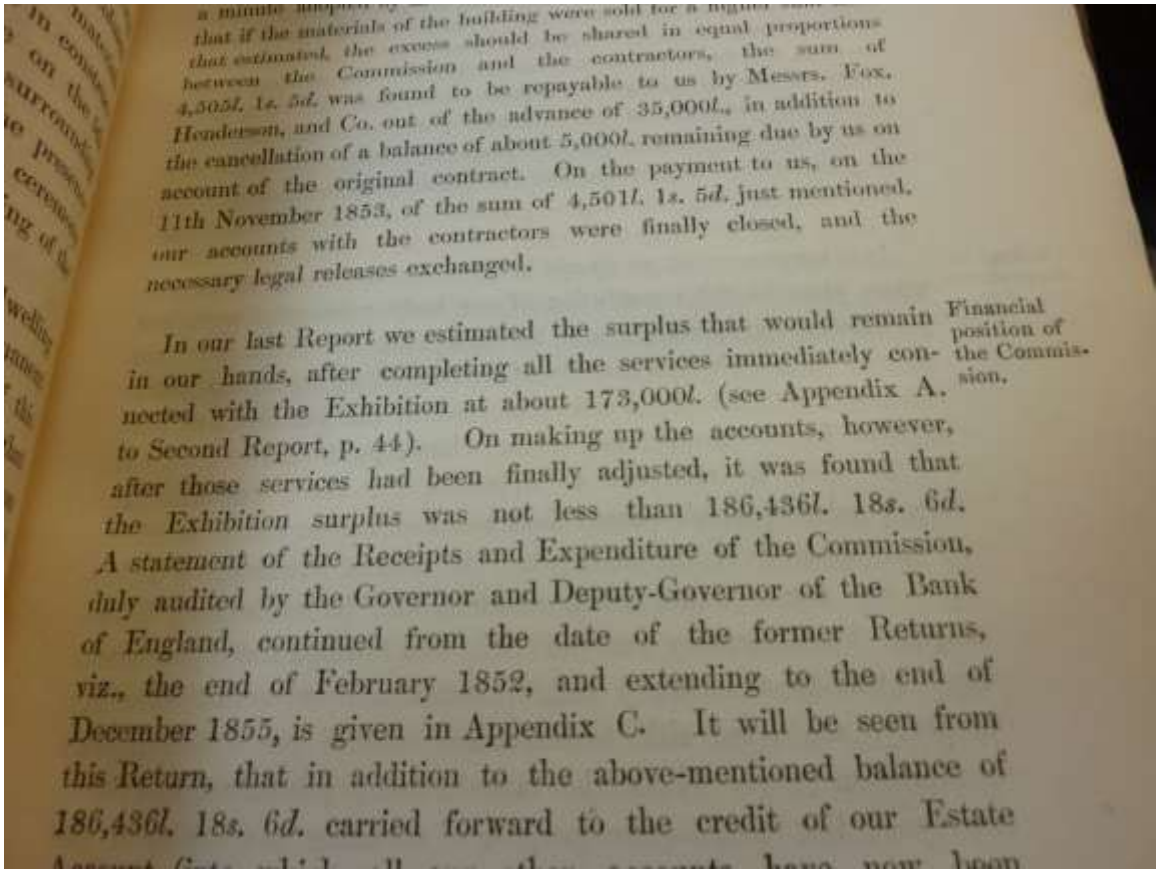
Chairman to the Building Committee, to undertake the arduous duty of general control. As officers acting under and responsible to him, the gentlemen who had been nominated by the Building Committee to assist them in the preparation of their drawings, &c., were reappointed, it being understood that the division of labour between them should be as follows:—Mr. Wild to make himself responsible for the engineering details, Mr. Owen Jones for the decoration, and Mr. Wyatt for the general building construction, fulfilment of contracts, extras, omissions, and the regulation of monthly accounts. In these departments each of those gentlemen acted during the erection of the Building; Mr. Earle being employed as Clerk of the Works, and Mr. Harwood as Surveyor.

Possession of the site was obtained on the 30th of July, and a boarding was immediately erected, enclosing it. Great ingenuity was bestowed upon the adaptation of mechanical contrivances to diminish and expedite labour; but it would occupy too great space were the Commissioners to attempt an account of them.

Numerous experiments were made to verify the stability of the work, and the consequent safety of the public; every cast-iron girder on being brought on the ground was weighed and tested in a hydraulic press. The wrought iron trusses were carefully examined, and their general conditions of efficiency determined by experiment and theory. Some of the most questionable points of the foundations were tested by loading them with extraordinary weights; the gallery floors

Fig. 9 Commentary on Quality Assurance and supervision.

And as would be expected, the accounting of all costs, including the construction costs was precise to the Farthing (1/4 of a penny). The exhibition was a popular and financial success with a final profit of £186,436 18s and 6d (in pounds, shilling and pence[2]). These profits were used to found the Victoria and Albert Museum and the Science Museum in London.



that if the materials of the building were sold for a higher sum that estimated, the excess should be shared in equal proportions between the Commission and the contractors, the sum of 4,505*l.* 1*s.* 5*d.* was found to be repayable to us by Messrs. Fox, Henderson, and Co. out of the advance of 35,000*l.*, in addition to the cancellation of a balance of about 5,000*l.* remaining due by us on account of the original contract. On the payment to us, on the 11th November 1853, of the sum of 4,501*l.* 1*s.* 5*d.* just mentioned, our accounts with the contractors were finally closed, and the necessary legal releases exchanged.

Financial position of the Commission.

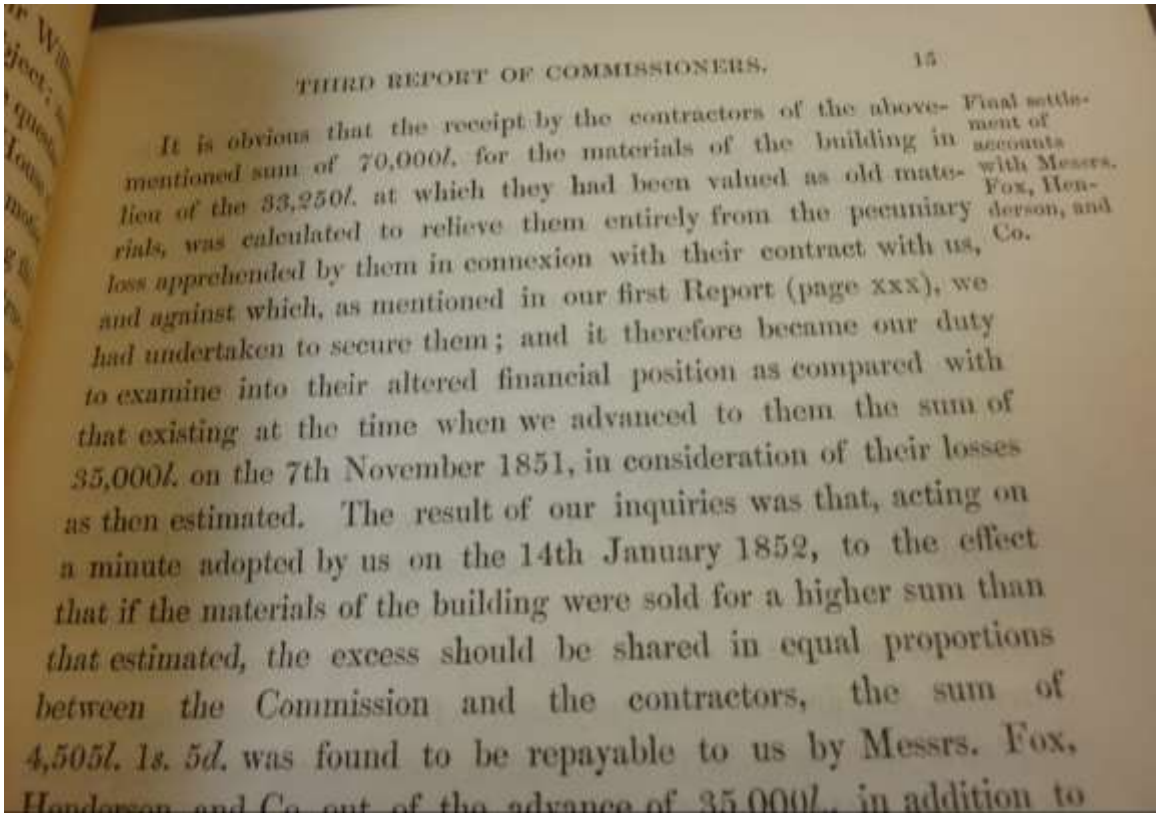
In our last Report we estimated the surplus that would remain in our hands, after completing all the services immediately connected with the Exhibition at about 173,000*l.* (see Appendix A. to Second Report, p. 44). On making up the accounts, however, after those services had been finally adjusted, it was found that the Exhibition surplus was not less than 186,436*l.* 18*s.* 6*d.* A statement of the Receipts and Expenditure of the Commission, duly audited by the Governor and Deputy-Governor of the Bank of England, continued from the date of the former Returns, viz., the end of February 1852, and extending to the end of December 1855, is given in Appendix C. It will be seen from this Return, that in addition to the above-mentioned balance of 186,436*l.* 18*s.* 6*d.* carried forward to the credit of our Estate

Fig. 10 The final profit.

There is also an interesting recognition of the problems of building such a massive structure in such a short time from a very basic initial design. There were many improvements in the design implemented as the work progressed causing the builder to incur a substantial loss, particularly as finishing late was not an option.

The Commissioners recognised this issue and made provision to compensate Fox, Henderson and Co for the losses that could be justified. Their original tender was £79,800, an additional £35,000 was approved in November 1851 and a final payment of £4,505 1s 5d closed the accounts after taking into account the sale of the structure for £70,000 to Fox, Henderson and Co for re-erection in what's now the suburb of Crystal Palace.

[2] For a description of pre-decimal English currency see:
http://resources.woodlands-junior.kent.sch.uk/customs/questions/moneyold.htm



THIRD REPORT OF COMMISSIONERS. 15

Final settlement of accounts with Messrs. Fox, Henderson, and Co.

It is obvious that the receipt by the contractors of the above-mentioned sum of 70,000l. for the materials of the building in lieu of the 33,250l. at which they had been valued as old materials, was calculated to relieve them entirely from the pecuniary loss apprehended by them in connexion with their contract with us, and against which, as mentioned in our first Report (page xxx), we had undertaken to secure them; and it therefore became our duty to examine into their altered financial position as compared with that existing at the time when we advanced to them the sum of 35,000l. on the 7th November 1851, in consideration of their losses as then estimated. The result of our inquiries was that, acting on a minute adopted by us on the 14th January 1852, to the effect that if the materials of the building were sold for a higher sum than that estimated, the excess should be shared in equal proportions between the Commission and the contractors, the sum of 4,505l. 1s. 5d. was found to be repayable to us by Messrs. Fox, Henderson and Co. out of the advance of 35,000l., in addition to

Fig. 11 Summary of the final account.

This understanding of the problem and willingness to work collaboratively to resolve it was no doubt helped by the presence of Sir William Cubit on the Commission. He owned a leading construction company and was a founder of what is now, 180 years later, the Chartered Institute of Building. However, for any Royal Commission to be able to properly dispense public money systems needed to be in place to properly quantify and cost the consequences of the changes needed to complete the building. This suggests sophisticated cost accounting processes within the building company as well as the Royal commission.

Conclusion

The reports of the Royal Commissioners show a very fine appreciation of governance. The objective of governance defined by Sir Adrian Cadbury Some 150 years after the Crystal Palace was built and the Great Exhibition staged is to *"holding the balance between economic and social goals and between individual and communal goals. The governance framework is there to encourage the efficient use of resources and equally to require accountability for the stewardship of those resources"*[3]. This defines governance as a pragmatic process focused on outcomes, not the blind imposition of undue process.

[3] For more on governance see:
http://www.mosaicprojects.com.au/WhitePapers/WP1033_Governance.pdf

The Royal Commissioners demonstrably achieved those objectives by ensuring adequate compensation to the builder and ensuring the preservation of the Crystal Palace despite Parliament voting against retaining it in its original location. Flexibility was shown when needed allowing work to start months ahead of the contract signing which in turn allowed the exhibition to open on time but financial and quality controls were strict and effective.

Additionally, the results of the building contract strongly suggest the project was effectively controlled and managed. But unfortunately whilst there are tantalising glimpses of sophisticated systems that could effectively manage extended off-site supply chains, large workforces and mechanised production; whilst dealing with the small tolerances allowed in modular cast iron, none of these have been preserved in the records of the Royal Commissioners. This is probably understandable given the Commissioners were the customer, not the builder and they had the overall responsibility of staging a massive event but it is disappointing.

The primary objective of my research[4] was to identify the processes used by Fox, Henderson and Co to sequence, schedule, organise and manage the construction of a very large building in a remarkably short timeframe, with particular emphasis on time management. These records were not found and consequently, we still don't really know or understand how the major construction works of the 18th and early 19th century were managed.

[4] This paper is one of a series looking at the history of project management and project controls. The research was focused on filling the gap in knowledge of project controls during the industrial revolution.

For more on the development of the concepts supporting the creation and use of bar charts see: http://www.mosaicprojects.com.au/PDF_Papers/P182_The_origins_of_bar_charting.pdf

For more on the development of scheduling in the 20th century see: http://www.mosaicprojects.com.au/PDF_Papers/P042_History%20of%20Scheduing.pdf

About the Author

Patrick Weaver

Author

Patrick Weaver, PMP, PMI-SP, FAICD, FCIOB, is the Managing Director of Mosaic Project Services Pty Ltd, an Australian project management consultancy specialising in project control systems and a PMI Registered Education Provider. Patrick is also the business manager of Stakeholder Management Pty Ltd. He is a Fellow of the Chartered Institute of Building, Australasia (FCIOB) and a Fellow of the Australian Institute of Company Directors (FAICD). He is a member of the PMI College of Scheduling, and the PMI Melbourne Chapter (Australia), as well a full member of AIPM, APM (UK) and the College of Performance Management. Patrick has over 35 years of experience in Project Management. His career was initially focused on the planning and managing of construction, engineering and infrastructure projects in the UK and Australia. The last 25 years has seen his businesses and experience expand to include the successful delivery of project scheduling services and PMOs in a range of government, ICT and business environments; with a strong focus on project management training. His consultancy work encompasses: developing and advising on project schedules, developing and presenting PM training courses, managing the development of internal project control systems for client organisations, and assisting with dispute resolution and claims management. He is a qualified Arbitrator. In the last few years, Patrick has sought to 'give back' to the industry he has participated in since leaving college through contributions to the development of the project management profession. In addition to his committee roles he has presented papers at a wide range of project management conferences in the USA, Europe, Asia and Australia, has an on-going role with the PMOZ conference in Australia and is part of the Australian delegation to ISO TC258. Patrick can be contacted at patw@mosaicprojects.com.au or at www.mosaicprojects.com.au.

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