Paper No. 6436

Port of London Authority: development of two dock areas, 1959†

by

Derek Ernest Glover, A.M.I.C.E.

Eric Newton, B.Sc., A.M.I.C.E.

Hilary Michael Dale, A.M.I.C.E.

and

Thomas Redvers Brown

Discussion

The Chairman (Mr J. H. Jellett) said that the Paper described some very careful planning of work which had to be carried out under difficult traffic conditions.

106. Had there been any compelling reason for adopting a 13-ft-6-in.-gauge crane track on a 50-ft-wide quay? At Southampton tracks up to 18-ft gauge were used on narrower quays with resultant lower wheel loadings, and benefit to the necessary foundation work. It was possible that the P.L.A. used the 13-ft-6-in. gauge in more restricted sites and had adopted it in the interests of standardization.

107. He felt sceptical about the suggestion that the 200-ft-span shed had cost little more than if it had been constructed in two spans of 100 ft. At Southampton research into the cost of shed construction had shown that whatever might be gained by eliminating columns in sheds was reflected in greater initial cost. Their traffic operators were very keen on having no obstructions in the shed, and the magnificent structure now being discussed offered opportunity for interesting research. Why not cost the cargo operations for a year and then compare them with the cost of operations conducted in the shed after dummy columns had been erected? Such columns ought not to be so slight as to be brushed out of the way by the traffic, and would need to be sufficiently like the real thing to impose the necessary traffic pattern. This would settle once and for all the question whether the cost of eliminating columns in transit sheds was really justified in operation.

108. It was stated that mobile cranes were not to be permitted to work inside the shed. Why, then, had 20 ft clear minimum head room been provided? Traffic operators were unwilling to stack up to the limit of the headroom and this had an unhappy effect on the capacity of the shed.

109. If cranes were not to enter the shed, what necessity was there for the expensive 20-ft × 20-ft doors? How manual would their operation be? Experience had shown that doors of that size, if intended for manual operation, were usually in the end operated with the assistance of electric trucks, the latter exerting pressure in places not intended by the engineer. Were the doors to be operated by a mechanical device of any kind, such as windlassing, to ensure that the manual effort was supplemented?

110. At Southampton, also, fibreglass had been used in roofs. Fortunately it had not yet become the subject of fire regulations, and he hoped that such regulations would not be so framed as to prevent the use that had already been made of fibreglass.

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† Proc. Instn civ. Engrs, vol. 15, p. 411 (April 1960).

Mr O. A. Kerensky (Partner, Messrs Freeman, Fox and Partners, Consulting Engineers, London) said that the lift bridge appeared to combine some very advanced ideas with an ingenious adaptation of available old steelwork. Strengthening and enlarging existing structures was always difficult, and probably this was no exception.

112. He had visited the area and had seen some of the traffic there on a Saturday morning. Why was the bridge only 20 ft wide? The approach roads were 26 ft wide. He feared that there would be congestion because a 20-ft carriageway was an outdated conception for two-way traffic, especially where it was of the heavy, industrial kind.

113. The design of the battled deck seemed to have been undertaken on an empirical basis, using American data that were quite excellent, and some knowledge of the results obtained with the experimental deck panels for the Severn and Forth Bridges. Could the Authors give the weight of the steelwork in the deck per square foot? He could not follow the arrangement of the butt joints in the deck plate. There seemed to be an excessive number of them. The only possible reason, it seemed, was to avoid field welding of the cross-beams to the plates; or was it because of limitations upon transportable sizes?

114. The reference in § 22 to the increase in load of 20% when members were subjected to reversal of stress due to bridge movement was not easily understood. Which loads were increased? Was it an allowance for dynamic effects during the opening of the bridge, or for fatigue due to a large number of stress cycles? If the latter, how many stress cycles—openings of the bridge—were envisaged each day? He was especially interested in this problem because today fatigue was very much in the foreground of engineering thought. This was an example of where fatigue provisions might be necessary in structural engineering.

115. It had required courage to adopt a new technique and try out materials for the roadway and footway surfacings weighing, in the case of the former, only 1/3 lb/sq. ft. If the experiment were a success it would influence the design of large-span bridges and movable bridges in the future.

116. What was the cost of the new surfacings used? How was the steel plate treated before the application of the surfacing? What tests were made to check the waterproofing, adhesive, and wearing qualities of the 2-mm-thick roadway surfacing material?

117. He had hoped to see the bridge open to traffic, but had found it in the vertical position. Accordingly, it was still too early to assess the effect of wear and tear. However, there were some signs of distress on the vertical surfaces of the steel kerb on the fixed part of the bridge. The roadway surfacing was turned up this face without being keyed to it. It seemed to be spalling off, probably due merely to bad workmanship, but what was the expected life of the material, and how was it to be maintained?

118. There were, on both sides of the bridge, "Customs fences". Did the Customs insist on this particular type of fence, or was it merely a utilitarian measure? It certainly spoilt a nice bridge. Could not suitable coping be provided?

Mr G. W. Smith (Traffic Superintendent, Port of London Authority) said that the heightening of the bridgework at the Surrey Commercial Docks meant that the bridge would now have to be moved only four or five times a day, and that barges would be able to pass under it without difficulty. Hitherto, it had been necessary to swing the bridge for the passage of craft perhaps 300 times a month.

120. It was very uneconomical to accommodate in a commercial dock vessels that would not be making use of the quay facilities. That had been happening at the Surrey Commercial Docks. It had been used by vessels of increasing draught and size, carrying timber from the Pacific seaboard of the North American Continent and discharging it overside. The widening and deepening of the Canada-Greenland Passage had made it possible to pass ships through into the Canada Dock where there was adequate water, and reserve the commercial berths, with their shed accommodation, in the Greenland Dock for the accommodation of general cargo ships.

121. So far as the 29/30 Berth was concerned, there had been increasing traffic in the

Finnish trade, and they had, for the accommodation of general cargo vessels, broken into what had been traditionally a timber discharging area.

122. The widening of the Connaught Passage had been made necessary largely by the increasing size of vessels trading to the South American Continent, in meat especially. Before the expenditure had been approved, intensive inquiry had been made into the desirability of accommodating such vessels in other parts of the Royal group of docks so that they would not have to go through the Connaught Passage, but other factors had to be considered. There were available, in the Victoria Docks, sheds especially equipped for the handling of chilled meat, and a decision had been made to widen the cutting.

123. From the dock-operating point of view, he looked forward to the time when the bridge abutment would be removed. It was not altogether a hazard, but it would be better removed. However, finance and such matters as local development had to be taken into consideration. The deepening of the cutting was also a possibility, but lay very much in the future.

124. Turning now to the No. 4 Berth: there were in the Royal group of docks more than fifty "ocean-going" berths. Of those, "D" Berth on the north side of Victoria Docks was the most intensively used by the North American trade. Vessels of the United States Line used it both for discharging and loading. No berth in the Royal group of docks dealt with so great a tonnage of both imports and exports in a 12-month period. It was clear that a very large shed would have to be built—and this had been done.

125. The fact that the shed was not centrally situated on the berth was not important. The traffic handled was such that one service carried a good deal of cargo inwards and outwards and another took cargo which could be discharged overboard. The latter operated from the west end of the berth—farthest away from the shed.

126. Mr Smith wondered how the cladding of the shed would stand up to the buffeting that it was likely to sustain.

127. As for the size of the doors, the shed had been designed for the accommodation of lift vans and large containers weighing up to 12 tons. If the necessary means of conveyance through the shed could be provided the whole width and height of the door would then be used. Existing equipment was very expensive, and could only be used for a specific purpose. They could not afford to have equipment costing that much money standing in a corner of the shed unused.

128. From a purely operating point of view, they had been amazed at the minor dislocation of traffic that had occurred during the whole of the works programme.

Mr I. S. S. Greeves (Superintendent Engineer in charge of dock works, John Mowlem & Co. Ltd, London) said that at the Connaught Passage it had become evident, after a study of the contract documents during the tender stage, that the successful completion would depend almost entirely upon the method adopted for the demolition of the old dock wall, particularly in the area adjacent to the British Railways tunnels which passed beneath the Passage.

130. Mr Menzies of the Metropolitan Construction Company had been very keen to demolish the wall by blasting, in a manner similar to that adopted at No. 1 Berth, Tilbury. However, there had been objections to this. First, the use of explosives was barred in the area adjacent to the tunnels. Secondly, no guarantee could be given that all concrete fragments would be cleared from the cutting between the passage of ships. Thirdly, there was the time needed to remove the demolished sections of the wall after blasting had taken place, since limited occupation only could be given.

131. There might have been delay to shipping while the cutting was being swept to ensure that the passageway was completely clear, and there was the possibility of damage to ships if any concrete was missed in the sweeping operations.

132. These thoughts had led them to explore the question of carrying out the demolition of the walls inside a cofferdam. The obvious way of dealing with the section over the railway tunnels was to use a limpet. They had used them before and felt

confident that the work could be done satisfactorily. The limpet dam could be extended to an ordinary sheet-piled cofferdam beyond the section where there was a concrete floor to the Passage.

133. The safety of the cofferdam would depend upon the provision of a robust fender which would be strong enough to withstand ships lying heavily against it. By pressing forward the construction of the new quay wall, they were able to provide "dead men" built into the coping, which took the thrust from a substantial fendering system.

134. While the dam was dewatered, approximately 360 ships of varying sizes, 1,200 tugs, and innumerable barges passed through the Passage without delay. The passage of these various ships caused ninety-four incidents, ranging from slight abrasions of the fendering to the occasion when a ship lay heavily against it, buckling the cofferdam piles about 16 ft below the surface.

135. The dolphins at each end of the cofferdam had been invaluable because they had enabled the ships to be lined up with the cutting before entering it. Consequently, they had taken the brunt of the damage.

136. As soon as the cofferdam had been dewatered, it was possible to carry out the demolition in the dry using plugs and feathers. These split the old mass concrete into blocks of up to 40 tons, the concrete shearing along the day joints of the original construction. For convenience in handling the blocks were sub-divided into pieces of about 2 tons in weight.

137. However, when it had been necessary for the divers to remove the remains of the wall left behind in the limpet section, it was interesting to note that it took them the same time to remove 220 cu. yd as it took to demolish 4,000 cu. yd in the dry. The best week's output being 500 cu. yd in the dry.

138. It would have been interesting to compare the rate of demolition of the dock walls at Canada-Greenland Passage, where blasting was employed, with that at Connaught Road, if only to satisfy the contractors that they had chosen the right method.

139. With regard to the reconstruction of 29/30 Berths at Surrey Commercial Docks, there were one or two points of interest. The old false quay had been supported on timber piles, and it had been found that the tops of the piles were rotten, so that it was not possible to extract them by direct pull.

140. It had been found that the pile shoes had become naturally cemented to the gravel and, in the course of time, had formed bulbous toes. After a number of experiments it was found that the best method of extraction was to use a high pressure water jet around the piles to loosen the ground and to break up the cemented gravel. This was done by attaching a 2-in.-dia. steel tube to the high-pressure connexion of the pump and working it up and down in the ground alongside the pile. When the pile had been loosened it was possible to lift it up in the leaders of a pile frame mounted on a floating craft.

141. With regard to the concrete piles driven, these were 14-in. $\times$ 14-in. prestressed concrete. The driving had been hard, but Mr Greeves did not agree with the Authors' suggestion that considerable damage had occurred to the tops. In fact not a single pile had to be reheaded.

142. Where piles had had to be pitched close to the gable end of the existing shed it had been necessary to alter the piling arrangements and to use pendulum leaders. By doing this it was possible to clear the apex of the shed by 18 in.

Mr T. E. Cook (United Kingdom Operating Manager, United States Lines) had been pleased to note that the damage to the fendering had been done mainly by barges, because there had seemed to be a notification of a claim almost every time a ship went through.

144. There was a programme of conversion to the use of containers, which would increase in the future. Containers 17 ft long and 8 ft wide and high were already being used, and it was expected that they would become longer still. An efficient method of handling the containers on a large scale in the shed had not yet been found. The wide range of equipment being offered was very expensive. The choice seemed to be be-

tween a fork-lift truck—which would carry the container in its teeth, as it were, and enter the shed like a huge T—or a device which would carry the container at the side. The question was whether the 20-ft doors would be big enough.

145. The ability of the shed cladding to stand up to rough treatment was most important. Already there had been some damage. Frequently this damage was attributed to the negligence of the stevedore, but repair expenses recovered from him would be reflected in the rates that he charged to the shipowner.

146. Reference had been made to the 20-ft-high cross-members, and to the fact that mobile cranes could not be used in the shed. However, some kind of lifting apparatus such as a fork-lift truck would have to be employed. There were large areas between the frames where the clear height was 30 ft or more. The use of equipment inside which would help with the stacking in those places had been envisaged, but there was a great fear of damage and so far there had been a ban upon equipment likely to lift cargo as high as 20 ft.

147. Everyone seemed afraid that if one of the cross-members were hit, a catastrophe would occur. Was this fear well founded?

148. Finally, on the question of stanchions, No. 4 Berth was being taken in exchange for "D" shed, the most heavily worked berth in the Royal group of docks, where the stacking space had been 120,000 sq. ft, although, for various reasons, it was not all usable. The new berth provided 140,000 sq. ft. It might seem a big project just to obtain 20,000 extra sq. ft, but the whole of the 140,000 sq. ft could be used completely. There was not the great loss of space owing to bays and walls with which they had had to contend in "D" shed. It was hoped that there would be nearly twice as much usable space.

149. Plans were being made to take the cargo of two ships. At "D" shed it had been possible to take the cargo of one ship only. It was far too early to say how it would all work out. The building had not been completely taken over. The cranes were not all installed and the shed was being operated on a one-berth basis.

Mr G. B. Godfrey (Tubewrights Limited) observed that in recent years his firm had been entrusted with the fabrication and construction of a number of large-span sheds for the Port of London Authority. They were particularly pleased that the Authority's own engineers had been responsible for the design of many of these buildings, including the interesting transit-shed described in the Paper. As the pioneers of tubular construction they welcomed this development, hoping that other designers would be encouraged by this demonstration that the design of tubular structures was by no means confined to the tube interests.

151. Nevertheless, there had been a number of facets of design or construction peculiar to tubular structures about which his firm had had to satisfy the P.L.A., either by existing research data or by new tests, that they were in fact efficient.

152. The bolted joints at the ends of the ties in the main girders were either conventional flanged joints or joints made by employing tubes with cruciformed ends, as shown in Fig. 29. Cruciforming was carried out by heating the ends of the tube and then pressing them to the shape indicated. Unless the tube diameter was very small, it was then possible to weld on a flange plate which would not project beyond the line of the tube, so that the joint was relatively unobtrusive.

153. For spans of more than 20 ft, tubes alone were not usually very efficient as purlins. The P.L.A. had adopted a number of interesting devices for their use in large spans. The system of propping in the new transit shed was quite common in Germany, where appropriate Standards and tables existed for such construction. In another shed, over a span of 25 ft, trussed tubes had been used. It was also possible, of course, to use light Warren girders embracing tubes or rectangular hollow sections.

154. Mr Godfrey stated that it was not in the best interests of tubes that they should be used just for the sake of using them. His colleagues and he had been intrigued by some of the methods employed by the P.L.A. to combine tubes and conventional sections. For the particular circumstances associated with the transit shed they did not

dispute that battened rolled sections formed the most efficient stanchions. However, they would have used single or twin battened tubes for the lower booms of the arched ribs, instead of the channel incorporated in the P.L.A. design.

155. The tubes for the transit shed had been pickled and phosphated and then given a coat of zinc chromate at the works. After erection there had been a coat of calcium plumbate, followed by one oil undercoat and one oil finishing coat. There was little doubt that these measures would give the structure a good start in life and should reduce the cost of maintenance to the minimum.

FIG. 29.—FORMATION OF A CRUCIFORM JOINT

Mr M. A. R. Davis (Engineer of John Mowlem and Co. Limited) referred to § 68 in which the work at the west knuckle was briefly mentioned.

157. The new line of the sheet-piling had intercepted an old quay consisting of timber piles, bracings, and a system of tie rods and concrete anchor blocks. At the start of the contract some trial trenches had been dug to establish if possible the outline of the existing works. Various timbers, etc., were revealed but it was not possible to determine the full extent of the existing piles and anchor blocks, etc. Approximately 100 piles—both timber and steel—were extracted to allow construction of the new works; the position of the new reinforced concrete piles were adjusted to clear, where possible, the existing obstructions.

158. The cofferdam enclosing the original south passage wall was approximately 350 ft long; the temporary steel piling at each end of the cofferdam was Larssen No. 4B section steel sheet-piles driven immediately in front of the toe of the dock wall. The central section approximately 130 ft long consisted of a limpet-type cofferdam where the floor of the passage formed the roof of the tunnels and service culverts. A chase was first cut along the toe of the wall by divers, into which the limpet piles were pitched; a seal was obtained by placing concrete under water between the back of the piles and the face of the dock wall.

159. A heavy fender which was provided along the whole length of the cofferdam sustained damage on numerous occasions but in the main protected the cofferdam. However, along the limpet section of the cofferdam the piles were deflected approximately 14 in. from top to bottom by a ship lying heavily against them. This necessitated additional stiffening work to the strutting inside the cofferdam, which allowed the work to proceed in safety.

160. Demolition continued until the toe of the original dock wall had been reduced to a minimum dimension, the remainder of the wall having been reduced to dock-bottom level. However, this section of the toe of the old wall failed just prior to completion of demolition, by cracking horizontally along the approximate dock-bottom level. Although the cofferdam was flooded by 12-ft depth of water it was possible, with extra pumps, to reduce the level of water to approximately 6 in. within 24 hours.

161. This allowed the preparation by drilling and placing plugs and feathers in the toe of the wall to facilitate subsequent demolition by divers under water.

162. Controlled flooding was commenced and the steel struts were removed after timber struts had been placed alongside; this enabled the whole of the temporary steel framing of the cofferdam to be removed without the use of divers since the temporary timber struts floated to the surface of the water on completion of flooding the dam.

163. The concrete seal of the limpet section piles was broken out with the toe of the old dock wall by divers. This seal had proved most effective and there was little leakage into the cofferdam during the whole of the time it was in use. Some crushing tests were carried out on concrete sections taken from this seal which had an equivalent 28-day strength of 3,300 lb/sq. in.

Mr Donald Jones (Assistant to Civil Engineer, South Wales Docks) observed that the Authors had stated in § 81 that the cost of providing a single-span shed of this type had been found to be very close to that of a double-span shed of the same width. He suggested that, using a similar form of construction with tied arch and welded tubular construction, the weight of steelwork per square foot of floor area covered could have been reduced to not more than 6 lb. instead of 9 lb. if two spans of 100 ft, with a centre row of columns of minimum spacings of not less than 40 ft had been employed.

165. Allowing for the increased cost of piling to the centre row of columns, the overall cost of the superstructure could have been reduced by at least 25%. It was quite a large figure in a shed of this size. Assuming that there were seventeen internal columns, it meant that the elimination of each column had cost more than £2,000. Had there been any real need for a single-span shed?

166. It facilitated the use of mobile equipment, and container traffic, but each stack of general cargo within the shed might be considered an obstruction. The shed floor was liberally covered with such obstructions.

167. In the South Wales Docks, columns at centres of not less than 40 ft had been found quite acceptable. The operating departments had claimed that they assisted in breaking the floor up into clearly defined stacking areas.

168. It was stated in § 89 that aluminium trough sheeting was being used in the new transit shed. The practice at the South Wales Docks, because of the vulnerability of the quayside elevation to damage by dockside cranes, was to use brickwork to full height with a parapet wall and gutter behind, quayside lights being mounted on top of the parapet behind the face-line of the brickwork. In places, brickwork was provided to a height of 10 ft to safeguard against accidental or wilful damage. Did the Authors anticipate any damage from such causes? Was the transit shed subject to the approval of Her Majesty's Customs? If so, what stipulations had been made regarding the fastenings of roof and side sheeting?

169. It could be seen from Fig. 24a that anti-condensation blocks had been provided. Had condensation on the underside of the roof given any cause for complaint?

170. He had had the good fortune to inspect the new shed by courtesy of the Chief Engineer of the Port of London Authority. He had found it very impressive, but wondered whether the biggest factor in the decision to adopt the single-span type of construction had been prestige value rather than economics.

The following contributions were received in writing.

Mr F. W. D. Davis (Retd) recalled that the steel lining to the twin tunnels to deepen the ship passage completed in 1937, initiated the modernization of the almost derelict Victoria Dock, the shed equipment of Berth No. 4 described in the Paper being a finishing stage.

172. The widening of the passage had not then been pressed. It involved the renewal of a heavy swing bridge, continuity of traffic over road and railway and in the fairway, the emergency running for the L.N.E.R. over the swing bridge, and uncertainty of the requirements of a proposed arterial road bridge for which a statutory reservation had to

be made. These difficult operations had yet to be tackled before the widening of the passage could be finalized. The alternative now appeared to be feasible of diverting the P.L.A. railway around the western end of the dock over the disused lock (filled in to prevent collapse), crossing the entrance to the pontoon dock by viaduct, and linking up with existing lines at the Connaught Road level-crossing. The existing connexion to the B.R. line would be retained for emergency purposes.

173. Manor Way and Silvertown Way provided ample road access to Silvertown and the south side of the docks, a foot bridge only was really necessary across the Connaught Road Passage, if a closing order was unobtainable, the new road bridge could occupy the site of the present railway bridge. The diversion of the railway would avoid placing another opening bridge with heavy concentrated load in close proximity to the tunnels and flexible quay walls.

174. The L.N.E.R. goods and passenger trains had been run over the swing bridge throughout the time the tunnels were laid off for the lining; the proposed diversion might therefore be acceptable for emergency traffic during the rare occasions it would be so required.

175. The Quebec Dock referred to in § 3 had been completed in 1925 to meet an urgent demand for additional berths. It was then a common occurrence during the season for thirty or more timber-laden vessels to be waiting off Southend for berths to become available at the Surrey Docks. It was the first instalment of a new dock 35 ft deep to replace the timber ponds and obsolete docks with an entrance from the river upstream and approximately parallel to the Greenland Lock. The closing of two small locks had increased the working of the Greenland Lock, which was more than 60 years old. The time was approaching when it would be necessary to lay off the lock for major repairs; an additional lock from the river would then be imperative as well as an enlargement of the now Russia Dock Passage to a size at least comparable with Greenland Lock.

176. Dock accommodation on the north side of the Thames within 10 miles of London was fully taken up and with the duplication of the Blackwall Tunnel, demand for more shipping space for general cargo at these docks might be expected.

Mr E. H. Vick (Divisional Engineer, London County Council) said that the London County Council sewer referred to in Part I of the Paper was the 4-ft-6-in. $\times$ 3-ft Rotherhithe Pier sewer, which was the only means of conveying sewage away from a considerable Thameside area around the Surrey Commercial Docks and into the low-level section of the South London main drainage system.

178. It had been essential to keep the old inverted siphon forming the part of the sewer under the Canada-Greenland Passage in operation until its flow could be diverted to the new siphon constructed by the Port Authority under the improved passage.

179. A penstock chamber at the upstream end of the old siphon had been severely damaged when the blow occurred through torn sheet-piling of Stage 3 cofferdam and sewage found its way inside that dam. Since the P.L.A. had no wish to pass sewage into the dock, pumping from the cofferdam had been suspended until the leak could be stopped. This had been done by isolating the short north-eastern arm of the Stage 3 cofferdam by driving the diaphragm indicated by dotted lines in Fig. 9a. This section of the foundation had been placed under water until the concrete had reached sufficient height to seal the lock.

180. All cracks above water in the sewer and penstock chamber had been caulked with "Philplug", these gaps in the brickwork ranged from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. in span, and the chamber had been shored internally with timber.

181. There had still been, however, too much ground-water and some sand leaking into the chamber to allow its base to be inspected and it had been decided to sink well points outside the chamber to attempt to lower the ground-water sufficiently for such inspection and further temporary repairs to be carried out.

182. Additional pumps had had to be put into operation on the low-level sewers at the Councils Deptford pumping station to induce lower sewage levels in the Rotherhithe Pier sewer where the repairs were required. Two well points, one on each side of the

sewer, had been drilled to well below the floor level of the penstock chamber but 6-in. electric pumps in each of them had been unable to cope with the ground-water. This had been caused by choking by fine sand although the well points had been completely surrounded by 9 in. of fine pea ballast. It had therefore been decided to seal the tops of the well points and connect vacuum pumps thereto, but this scheme met with no greater success since practically no vacuum could be obtained in the wells, probably because the ground was full of air as a result of compressed-air tunnelling being carried out below.

183. A hole had then been bored under water through the floor of the chamber (3 ft 6 in. of brickwork and concrete) and a grout pipe, reaching to surface, inserted. Ground-water pumping had then been stopped and when the water became static 17 cwt of cement grout had been poured into the pipe and allowed to flow into the suspected cavity below the floor. The inflow of water had been thus reduced so that sand on the penstock-chamber floor could be removed and a sump cut in the floor to enable water to be pumped from the chamber. It had then been seen that the floor was intact but had dropped away from the walls of the chamber, the resulting gap being $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. This gap had been caulked and half the floor, which was 12 in. below the level of the incoming and outgoing sewers, had been covered with concrete. A concrete wall to contain sewage to one siphon pipe had been built along the slab edge. A further grout hole had been bored through the uncovered half of the floor and after 1 ton of cement grout had been pumped through it the concrete slab had been completed.

184. The sewer had been maintained in these conditions until the new siphon came into use about 15 months later, after which the old siphon had been partly demolished and partly filled in by the Authority's contractor. The temporary sewer repairs had been carried out by John Mowlem & Co. Ltd, who had been the Council's jobbing works contractors at the time.

Mr John Menzies (Director, Metropolitan Construction Company Limited) observed that the work of demolishing the old wall at Canada-Greenland Passage was not yet complete, but the indications were that the overall cost would not in fact be very different from that at Connaught Passage when the cost of the cofferdam was taken into account.

186. A cofferdam had not been practicable at Canada-Greenland Passage and there had therefore been no alternative to the use of explosives. The site was very congested and considerable care had had to be exercised in their use, particularly because of the two new service tunnels which had been completed before the major demolition work commenced. The work of demolition fell into two main sections—the deepening of the invert by breaking out the top 4 ft 6 in. and the demolition of the old wall.

187. It had been calculated that a maximum detonation of 25 lb. of submarine blasting gelatine would be permissible in the invert, this had proved to be the case and no damage to the tunnels or surrounding structures resulted. Blasts of up to 100 lb. total had been fired but these had been reduced to 25 lb. instantaneous detonations by the use of millisecond delay submarine detonators. In all blasts the cartridges were initiated by double taped Cordtex. The charging holes were drilled at 2-ft 6-in. centres and the resulting debris was being got out by $1\frac{1}{2}$ -cu.-yd grabs worked by the main contractors' derricks or by a large navy.

188. The holes for the invert blasting were $2\frac{1}{2}$ in. dia. and were drilled by special wagon drills on mountings fixed on a barge.

189. Because shipping continued to use the passage it was a condition that the debris produced by a blast should not be higher than 4 ft above the original invert level. The maximum "lift" in the debris so far recorded was approximately 1 ft 6 in.

190. The same condition applied to the debris resulting from the demolition of the wall, but in this case it had been felt that the risk of a pile-up of debris above the permitted level by the demolition of a complete section of the wall would be too great. The wall, however, had been found to have been constructed in approximately 4-ft layers and the novel method had been adopted of demolishing the wall by explosives by

layers. The holes for the charges in the first two layers had had to be drilled by divers, since there had been insufficient depth of water for the drilling barge, but the layers below this had been drilled from the barge. Charging had of course been done by divers. Sections between 70 and 80 cu. yd of each layer had been blasted at a time without any serious build-up of debris in the invert. As a precaution the section of invert adjacent to the portion of wall being demolished was blasted and grabbed out before the wall was demolished.

The Authors, in reply, first drew attention to some errors in the Paper:—

§ 78. The words “in the dry” should be deleted from the last item.

§ 93, line 2. For “8 in.” read “6 in.”

Appendix, Table 1. The cost of latrines, gear store, and substation should read £14,000, not £38,000.

192. In reply to the Chairman's question on the 13-ft-6-in. crane gauge on the new quays, the Authors said that that was the standard in the Authority's docks for all such berths, and it was maintained for new works unless special consideration of out-reach and wheel loads outweighed the advantages of crane transferability.

193. Referring to the question of wider single-span sheds (§ 107), the operating officers concerned were unanimous in their opinion of the need for one clear span at No. 4 Berth, provided that it could be economically designed and constructed. There was no doubt that the cost of the 200-ft-span roof structure was higher than the cost of two 100-ft spans. It should be remembered, however, that the main roof framework represented only one-third of the cost of the whole shed, and the single-span construction showed savings in columns, foundations, guttering, and drainage. Fig. 30 gave outlines and foundation data of five sheds, recently constructed by the Authority, with spans exceeding 100 ft. Table 20 gave the approximate costs, and it would be seen that the costs per square foot of floor area compared favourably with those of much smaller sheds⁸. In the case of the structure described in the Paper, the difference in total cost between the shed as constructed and a shed having twin 100-ft spans had been estimated at no more than 5% of the total cost.

194. Prestige value had certainly not been a factor (§ 170) in the decision to adopt single-span construction; this was clearly demonstrated by Table 20.

195. The clear height in the shed and the door openings had been adopted as standard for all new transit sheds from mechanical-handling considerations, and included reasonable stacking height for fork-lift trucks and provision of clearance for large containers. Aluminium construction for the doors had avoided the need for mechanical operation; indeed, the doors could be easily moved with one hand.

196. Turning to Mr Kerensky's question regarding the design of the Canada/Greenland Passage bridge, the road traffic at that point consisted of slow-moving heavy vehicles; there was also need to cater for crowded pedestrian conditions during certain periods of the day. It had been accepted by the road Authority that the best use of the available width would be made by the adoption of a 20-ft carriageway.

197. The weight of the battled deck floor was 40 lb/sq. ft including the plating of 9-in. $\times$ 4-in. B.S.B. stringers. Inclusion of the cross-girders would increase this weight to 48 lb/sq. ft; each figure excluded the surfacing. Mr Kerensky was correct in assuming that the large number of butt joints in the deck plate avoided site-welding of the cross-beams to the plates. The setting-out of the deck plating and short lengths of stringer had to be particularly accurate in order to ensure the correct vertical curve of the roadway; this was more easily done in workshops.

198. The cost of the surfacing material had been about 30s./sq. yd, and included sand-blasting the steel plate before application. Trial patches had been applied to the

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⁸ E. Newton, “Some recent sheds in the Port of London”. Dock Harb. Author., vol. 41 (1960), p. 79.

ITEM IN TABLE 20	NUMBER, LOCATION, AND FLOOR AREA	DIMENSIONS AND TYPICAL SECTIONS	FOUNDATIONS
(a)	1-5 Acorn Yard. 121,000 sq. ft		Four 12"-sq. x 30'-long R.C. piles per column
(b)	5 Junction Dock, India and Millwall Docks. 37,000 sq. ft	Future extension R.C. columns Brick firewall 	R.C. footings 10' x 7½' and 7' x 5½'
(c)	4 Royal Victoria Dock. 145,000 sq. ft shed; 16,000 sq. ft canopies		Two 14"-sq. x 40'-long R.C. piles per column
(d)	B Millwall Dock, outer. 32,000 sq. ft		Mass concrete bases 10' x 5' x 4½' deep
(e)	G Millwall Dock, inner. 52,750 sq. ft		Mass concrete bases 10' x 5' x 5' deep

FIG. 30

tail plates on the old swing bridge, and the manufacturers had given evidence concerning the waterproof and adhesive qualities of the material. None of these tests could be considered to be rigorous enough to give reliable information about the ultimate wearing qualities of the material as a road surfacing. It was doubtful if an area much less than that provided by the deck of the new bridge would be suitable for this purpose; and in view of the considerable saving in weight and the possibility of its wide application if it proved satisfactory in practice, a decision to use the material had been made. The unsatisfactory patches over the roadway, observed by Mr Kerensky, had resulted from an underestimation of the degree of cleanliness required to ensure adhesion between layers of epoxy resin material. These patches had been repaired before the bridge had been put into operation.

199. The 20% increase in load (§ 114) was a comprehensive allowance covering dynamic forces and fluctuation in stress. B.S.153: 1937, Part 3b, to which the working stresses conformed, had not covered fatigue as comprehensively as the 1950 edition.

TABLE 20.—See also FIG. 30

Item in Fig. 30	Shed paving	Roof and side cladding	Total weight of steel-work: lb/sq. ft	Rolled steel: % weight	Tubular steel: % weight	Average cost of steel-work erected and painted: £ per ton	Cost of complete shed persq. ft: s. d.	Year of construction
(a)	6-in. R.C. slab on rolled hardcore	"Big Six" corr. asb.-cem. roof sheeting. 18 S.W.G. galv. corr. M.S. side sheeting	6.7	2	98	125	21 0	1956
(b)	—do.—	"Big Six" roof. 18 S.W.G. alum. trough side sheeting	4.9	1	99	134	27 6	1957–58
(c)	—do.—	18 S.W.G. alum. trough roof and side sheeting	9.0	40	60	142	26 9	1959–60
(d)	—do.—	—do.—	6.0	53	47	139	27 6	1960
(e)	—do.—	—do.—	6.3	49	51	134	26 0	1959

The estimated number of bridge movements in a life of 70 years was of the order of 120,000.

200. The bridge had been subjected to a full design test load, and it produced in the main girders a deflexion of 2 in. as compared with the calculated figure of $2\frac{1}{2}$ in. In the cross-girders those figures had been 0.32 in. and 0.38 in. respectively.

201. Mr Kerensky had questioned the appearance of the Customs fence. It had to be considered whether or not a special design should have been made in this particular instance. The fence provided was standard throughout the Authority's docks, and the design had been adopted some years previously—to give a reasonably suitable appearance in the many different environments in the dock areas.

202. Mr Greeves had described the reasons for the Contractor's preference for a cofferdam rather than blasting at Connaught Road Passage. The success of the method was emphasized by Mr Smith's comment on the comparatively minor dislocation experienced by shipping. In the light of experience gained during the work it now appeared that the work at the west knuckle would have been more satisfactorily carried out inside the cofferdam, thus avoiding some of the difficulties described by Mr M. Davis (§§ 158 and 160). The comparison of demolition data asked for by Mr Greeves (§ 138) had been given by Mr Menzies (§§ 187 *et seq.*). Although Mr Greeves had said that it would have been interesting to compare the rate of demolition with that at

Connaught Road, the Port Authority had in both cases accepted the Contractor's proposals, and the Authors considered that the most suitable method had been chosen in each case. Because of the traffic situation it was very doubtful if a cofferdam could have been accepted at the Canada/Greenland Passage. At both sites the old concrete had generally proved to be of good quality, and tests at Connaught Road had shown the crushing strength to be of the order of 2,500 lb/sq. in.

203. Mr Cook, who had referred to the operating conditions, had been concerned with many of the basic planning discussions for No. 4 Berth. The Authors hoped that drivers of mechanical equipment would never be tempted to test the strength of the main roof ties. However, the design ensured that if one tie were to be accidentally severed there would be no progressive collapse.

204. The ability of the aluminium side sheeting to resist accidental blows from operations, particularly on the quay side, had been questioned. This was fundamentally a question of economics; capital cost had been weighed against inconvenience and cost of repairs. The behaviour of the aluminium sheeting was being very carefully watched.

205. In reply to Mr Jones's question on fastenings (§ 168), the fastenings in the roof and side sheeting of the new transit shed did not differ basically from those of other sheds. They had been approved by H.M. Customs, whose main requirement had been the burring-over of the last threads of the bolts after the sheets had been fixed. For many years the Authority had used anti-condensation blocks with metal roof sheeting, and this had eliminated condensation troubles.

206. Mr Godfrey had raised the question of whether tubes might not have been preferable to channels for the lower booms of the arch ribs of the transit shed. It had been thought, however, that under certain very unfavourable wind and snow conditions the purlin props might exert unsymmetrical loads on these booms. A channel laid flat provided a much better section for dealing with the resultant horizontal forces than did either single or twin-battened tubes.

207. Mr F. Davis had recalled the difficult and successful work in deepening the Connaught Road Passage, with which he had been so closely concerned. He had rightly called attention to the difficulty that would certainly arise when the time came to complete the widening of the passage, but his suggestion that the railway bridge be transferred to the Western Entrance Lock, and his other remarks connected with road traffic, raised planning considerations that were outside the scope of this discussion. The subject had been much debated since the publication of Sir Charles Bressey's report in the Ministry of Transport's Highway Development Survey, 1937. Incidentally, the Port Authority had recently authorized the re-opening of the Western Entrance for use by barges, and preparatory work was in hand.

208. The Authors agreed that repairs might have to be carried out at the Greenland Lock in the foreseeable future (see § 175), but it was doubtful if the very heavy capital cost of an additional entrance was warranted on those grounds alone, even if a suitable site could be found in this highly developed area. When repairs became necessary a method of carrying them out with minimum interference to traffic would have to be found.

209. With regard to the development of general cargo berths at these docks, it should be borne in mind that the demand for timber berths, although seasonal, was at times embarrassingly high.

210. Finally, the Authors thanked Mr Vick for the additional reference to the damage to Rotherhithe Pier sewer. It had been a particularly worrying event and, if it had not been adequately and speedily dealt with by Mr Vick, could have had very serious consequences. It was instructive to note that the well points used in this emergency had not been as successful as the Benoto Wells described in the Paper but not available to the L.C.C. at that time.