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SUEZ CANAL

BRIDGE COMPLETION REPORT

1943

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SUEZ CANAL BRIDGE - COMPLETION REPORT.

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1943

COMPLETION REPORT - SUEZ CANAL BRIDGE.

TRODUCTION.

neral

At the outbreak of War the sole method of crossing the Suez Canal was by ferry. Several ferries existed, one at Kantara for railway traffic and a number of smaller ferries for road traffic. During the war the Army has built a number of pontoon bridges for road vehicles and an additional rail ferry.

During 1917 a swing bridge was constructed across the Canal at KILO 43 approximately 5 kilometres to the North of Kantara. This bridge consisted of 5 spans with 2 swing spans giving openings of 42 metres and 9 metres. The main swing span was pivotted at one end, the other end resting on barges. The free end of the span was floated round as required and was jacked up when in the "made" position. This bridge, which was entirely satisfactory, was removed in 1921.

Early in 1941 various schemes were worked out to provide a similar type of bridge just North of Kantara, on almost the identical site to the old bridge. The Suez Canal Company and the Admiralty insisted on the opening being 67 metres as against 42 metres in 1917.

The first design consisted of one swing span with a pivotted end and the other end floating on a barge. The E.S.R. Bridge Engineer submitted a proposal for a double leaf swing bridge carried on two piers and anchored at the abutments. This design was considered superior to the first design, and was adopted.

In the middle of May, 1941, Messrs. Braithwaites & Co. (India) Ltd., were instructed to carry out the construction.

oice of Site

In July 1941 the proposed site was changed from approximately Km.43 to Km. 64.25.

The new site was selected for the following reasons:

(1) The sweet-water canal did not lie between the ISMAILIA - PORT SAID Railway and the SUEZ Canal, as it did at kilo 43.

(2) The approach to the bridge from the PORT SAID - ISMAILIA line does not involve excessive curves or gradients.

(3) The new line between Kantara East and El Shatt could be used for the approach on the Asia bank without laying much additional track.

(4) The proximity of railway & Canal Stations at El Firdan simplify control.

(5) A minimum distance of 600 metres clear of the curve in the Canal to the North of the site was required for reason of navigation.

ecution of e Work.

The construction of the bridge was planned and supervised by Col. K. N. SHEER, formerly Director of Railways and later D.D.Tn.(Construction), and his staff.

The bridge was designed by the Assistant Chief Engineer (Bridges) E.S.R., Dr. SAYED ABDEL WAHID. The survey was made by the Australian Rly C. & M. Group, R.A.E.

A contract for the supply and fabrication of the steelwork and the construction of the bridge was given to Messrs. Braithwaites & Co., (India Ltd., of Calcutta, who were also responsible for the production of the detailed drawings.

mpletion

The bridge was opened to rail traffic on August 7th, 1942.

DESCRIPTION.

Design.

The bridge was designed for the E.S.R. Train - Type B plus half the usual impact. This corresponds to a BSS 16.3 Unit Railway Loading.

The deck was designed to carry a Class 70 Military Road load.

General.

The bridge is a two-leaf swing bridge of a novel design. The main pivot piers are set at 250'-4" apart, centre to centre. Each span is 247 ft long, made up of an anchor arm 117 ft long and a cantilever arm 130 ft long. When the bridge is "made", the end of each anchor arm sits on an abutment which also acts as an anchorage. The two cantilever arms are connected by locking pins.

The turntable steelwork is so arranged that each main truss has approx. a single point bearing at the pivot pier, when the bridge is made.

Abutments.

The abutments are of mass concrete with a reinforced concrete toe. They are founded on sand approx. 7 ft. below the mean water level of the Canal. Reinforced concrete wing walls are provided.

Steel anchorages are concreted in the abutments, so arranged to take a vertical uplift from the span. Wedges of standard design are provided to take the vertical downward load from the span.

Pivot Pier.

Each pivot pier consists of an octagonal R.C. slab, 5 ft thick and 36 ft across the flats, carried on twelve C.I. screw cylinder piles. Four fender piles are provided at the corners, and the whole is protected by 12" x 12" timber fenders.

The main piles were founded at R.L. - 11ft and the fender piles at R.L. - 2 ft. The underside of the slab is about 3 feet above mean water level (R.L.39.8), and the main piles are 74 feet long. The fender piles are 65 feet long.

The canal bed varies at the pivot pier from R.L. 45 ft. to R.L. 29 ft., the pier being situated on the dredged bank of the canal.

Each cylinder pile consists of a screw 7'-6" diameter, carrying C.I. cylinders 3 ft. external diameter and $1\frac{1}{8}$" thick. The cylinders are in 9 ft. lengths and bolted together by internal flanges. The screws consist of two C.I. blades each forming roughly a 160° section of helices of 24" pitch, the helices being half a pitch apart. Open nosed screws were used throughout.

Superstructure

Each span consists of two main trusses of the Warren type with sub-panels, the ends of the cantilever arms being reduced to half the depth of the remainder. The trusses are at 19 ft. centres, giving width for a single line railway or a 15 ft. roadway.

Lateral bracing is provided throughout the botton chord, and in the top chord where the truss is the full depth. Sway frames are provided at each main vertical in the deep part, and knee braces at each vertical where the truss is reduced in depth.

28-32 ton/sq.in. mild steel was used throughout.

The deck consists of steel cross girders and stringers carrying 10" x 8" cross timbers at about 2 ft. centres.

The rails are fixed on these cross timbers, and the remaining space filled with 12" x 6" longitudinal timbers to form a roadway.

Turntables.

These were obtained from the E.S.R. and are of common design.

That used for the Afrion span was an unused turntable made for a projected bridge at Benha. This turntable has a pitch circle diameter of 27'-$2\frac{1}{2}$".

Turntables (cont'd)

That used for the Asia span was the turntable of a bridge across the Nile at Nag Hamadi, which was replaced in 1936. This has a pitch circle diameter of 15'-5". The main trusses lie within the Africa turntable, but outside the Asia turntable. To stabilise the bridge at the latter, brackets were erected carrying wheels which run on a rail on the pier.

The design of the turntable steelwork is novel, owing to the necessity of obtaining a single point articulated support for the trusses.

Turning Gear.

Each span is turned by two hand capstans operating, through spur gearing, pinions on a rack attached to the lower roller path of the turntable. Each span can be turned easily by six men, the time for swinging from the "cut" to the "made" position being about 5 minutes.

Locking Gear at Centre.

This consists of a steel pin of rectangular section 10" x 6" carried in two C.I. housings at the end of each truss of the Africa span. Each pin has a rack machined in it, and the two pins are slid horizontally and longitudinally through the housings, by means of pinions operated through worm gearing by a hand capstan, so that their ends enter C.I. housings on the Asia span. All the housings are provided with phosphor-bronze faces, and there is about ⅛" clearance in each housing in both directions. The nose of the pins are tapered to facilitate entry.

Fishplates.

Mechanically operated fishplates were provided by the E.S.R. at both abutments and at the centre.

Expansion Joints.

Rail expansion joints were provided at each abutment and on the Asia span at the centre of the bridge.

Signalling.

An interlocking system is provided, whereby the signals may not be operated until the locking pins at the centre have been driven home and the fishplates made at the abutments and the centre of the bridge.

Dolphins.

To protect the superstructure when in the "cut" position, dolphins were constructed to the north and south of each pivot pier. Each dolphin consisted of an R.C. slab 5 ft. thick, carried on three screw cylinders and one 3 ft. dia. cylinder without a screw. The four piles were braced with heavy steelwork and timber fenders were provided.

Operation.

The bridge is entirely hand-operated.

The operations to "make" the bridge are as follows:-

(1) Swing the two spans.

(2) Wedge up at the abutments.

(3) Drive the locking pins at the centre.

(4) Fish the rails together at the abutments and at the centre.

Operations (2) and (3) are usually done simultaneously. The total time for "making" or "cutting" the bridge by the E.S.R. crews is from 10 to 15 minutes.

ADMINISTRATION

Staff.

The arrangements for the construction of the bridge were made by the D.A.D.Tn(Bridging) and the S.C.Tn (Bridging). These officers, the former a qualified structural engineer and the latter a qualified civil engineer, both with considerable experience, were responsible for the arrangements for quartering, rationing and providing other services to the contractors' staff and workmen.

They also placed orders for all material and plant not supplied by Messrs. Braithwaites, and ensured that it was delivered when and as required, and generally organised the construction. Shortly before construction was commenced, a construction liaison officer was appointed to supervise the work at site. This officer was a qualified civil engineer with considerable experience in the design and construction of long span bridges and of civil engineering in Egypt and the Middle East.

Throughout the construction, close and friendly relations were maintained with Messrs. Braithwaites' staff and the E.S.R. Bridges dept., and it must be emphasised that the presence of experienced civil engineers on the army staff was an important factor in the rapid and successful completion of the bridge.

Drawings.

General drawings of the bridge were prepared by the E.S.R. Bridges Dept. These were passed to Messrs. Braithwaites who prepared ~~the~~ detailed drawings in their office in Calcutta. To facilitate this, Messrs. Braithwaites' works' manager visited Cairo, and discussed the details with the E.S.R. bridge engineer and the D.D.Tn (Constr) and his staff. This saved time which would otherwise have been wasted in sending drawings to and fro between Cairo and Calcutta. The detail drawings were sent to the D.D.Tn Construction, who forwarded them to the E.S.R. Bridges dept. for the design to be checked. Owing to the urgency of the job, the fabrication of the steelwork was commenced immediately the drawingswere completed, without waiting for approval. This step was justified, as the modifications required after the design had been checked were, with one exception, of a minor nature and easily effected at site.

The exception was in the turntable steelwork at the Africa pier. Messrs. Braithwaites interpreted the designer's wishes incorrectly, and four new girders had to be made in Cairo and incorporated in the steelwork at site. These modifications did not, however, cause any appreciable delay.

Financial Arrangements

The Suez Canal Bridge was ordered from Messrs Braithwaites & Co., (India) Ltd., in the middle of May, 1941 and from then eleven months elapsed until the contract was signed in the middle of April, 1942.

During this period considerable correspondence circulated between the War Office, G.H.Q. M.E.F. and Messrs Braithwaites and all work was carried out in accordance with D.G.Tn's CEME/8950/Tn(F) of 17th May, 1941 to Department of Supply Govt. of India.

The work of the Army supervising staff was by no means simplified by this arrangement. The consequences arising from this condition could be very serious indeed if one were dealing with an unscrupulous contractor. It is pointed out that Messrs. Braithwaites were exceedingly helpful and that few difficulties of this nature arose.

The Contract was placed on terms according to the Chief Controller of Purchase (M) letter MP-9751/S-2 of April 18th 1942 in addition to the Standard Condition of Contract (I.S.D. Form 12-C(S))

The cost of the bridge was made up as follows:-

I. Fabrication and supply of material.

(a) Materials at cost.
(b) Drawing Office cost to be salaries + 30%.
(c) Direct Labour in fabrication in accordance with usual costing practice.
(d) Workshop and Office on-cost charges as percentage on direct labour.
(e) Miscellaneous Expenses.

Financial Arrangements.

II. Site expenses which include:-

(a) Salaries to Establishments employed at site.
(b) Erection on-cost at 15% erection labour.
(c) Monthly hire on loaned major plant and tackle.
(d) All tools (Not included in (c))
(e) Consumable stores.
(f) Site allowances and expenses to Staff.
(g) Miscellaneous site expenditure.
(h) Head Office expenses at 10% of total cost above.

III. Cost of passages, passports and travelling expenses of staff and labour to and from the site.

IV. Profit. (a lump sum of £5,000)

V. Agent's Commission.

VI. Special Terms. (to be paid by Army).

(a) All transit charges from Engineer Store to site.
(b) Cost of return of major plant to India from site on completion.
(c) Insurance premia on plant and material.
(d) All costs due to damage by enemy action.
(e) Compensation to staff or workmen if injured, fatal or otherwise, by enemy action.

the main line for the purpose. Messrs. Braithwaites did not make any provision for off-loading from rail or from road, although a good road passed through the yard. Heavy goods delivered by rail were transshipped to barges at Firdan wharf and towed to the site from there.

A tubular guyed derrick was supplied by Messrs. Braithwaites, but was not erected.

Local Supplies

At the commencement of the contract, Messrs. Braithwaites were repeatedly asked to furnish a comprehensive list of their requirements. Eventually a list was obtained but this subsequently proved to be very incomplete, and requests for plant, tools, and stores were received almost daily throughout the work.

IV SUPPLY OF MATERIALS.

Materials were obtained from the following sources:-

Structural Steelwork C.I. Screw Piles	Messrs Braithwaites & Co., Calcutta.
Turntables	E.S.R.
Turning and wedging gear	E.S.R.
Locking gear at centre	Messrs. Braithwaites.
Gravel and Cement.	Local purchase thro' D.D.W.(S).
Reinforcing bars	D.D.W.(S).
Timber.	D.D.W.(S)
Petrol, paraffin & A.G.O.	R.A.S.C.
Coal	Tn. Stores.
Coke	R.A.S.C.
Lubricating Oil	Tn. Stores.
Camp equipment	R.A.O.C.
Plant, tools, & consumeable stores.	(Messrs. Braithwaites & Co., from Calcutta (and by local purchase. (Tn. Stores (I.W.T. (E.S.R. (S.A.C.R.R. (R.A.O.C. thro' Tn. Stores (Ports & Lights Admin., Alexandria.
Shuttering timber	(Tn. Stores (Salvage.

Materials from India.

C.I. steelwork & Plant from India were discharged at Suez, Fanara, Abu Sultan, Port Said and Alexandria. The total quantity was 1800 tons and all of this was delivered at site. Five pieces, weighing about 3 tons total, went astray from the second shipment, and were delivered at site about three months after the main part of this shipment, thus being temporarily lost. The discharge of the ships was checked by the Tn. Stores representative at the ports, assisted in the case of large shipments by the Tn.C.L.O. (Bridging)'s staff. In most cases, the material was shipped to site by I.W.T. craft.

The state of discharge of vessels was reported daily to the Tn. C.L.O.(Bridging) by the Tn. Stores representatives, but the efficiency of the system was impeded considerably by there not being a telephone at the site.

All the steelwork for this job was painted either black or grey. The distinctive colour was largely responsible for the delivery of all the steelwork.

Handling at Site.

Messrs. Braithwaites erected a 15 ton steam crane on the Africa shore for the dual purpose of construction and off-loading materials. A 10-ton steam crane erected on pontoons for construction on the Asia side was also available for handling materials from mid-January until construction of the Asia side was commenced in mid-March.

Arrangements were made with the E.S.R. to construct a siding for delivery of materials. This was not completed until December -? and was comprised of the main approach to the bridge with a turnout from the main line for the purpose. Messrs. Braithwaites did not make any provision for off-loading from rail or from road, although a good road passed through the yard. Heavy goods delivered by rail were trans-shipped to barges at Firdan wharf and towed to the site from there.

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Local Supplies

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Local Supplies (cont'd)

It was found that a period of several weeks usually elapsed between an indent being placed and the delivery being obtained from D.D.W.(S). It was also found that items purchased on the local market could be obtained much more quickly through Messrs. Braithwaites' agent in Cairo, than through the army organisations.

The main difficulty with local supplies was transport, particularly in the case of items from outside Moascar area too small to make a complete wagon load. If despatched by rail, such goods almost invariably went astray, and area transport is not allowed outside the area. These difficulties would have been eliminated if a 30 cwt. lorry had been attached to the job.

Later, it was found that items from R.E.B.S.D.'s could be sent with other goods to R.E. Stores, Moascar, and local transport arranged from there.

Tools etc. were not always delivered from Tn. Stores as promptly as desired. This was usually due to lack of sufficient transport. The absence of a telephone at site also caused difficulties and much waste of time.

CONSTRUCTION

The construction divided itself up into the following main works:-

(1) Preparation.
(2) Screwing cylinder piles.
(3) Erection of superstructure.

The Africa piles were screwed first, and the Africa superstructure was erected whilst the Asia piles were being screwed. The Asia superstructure could not be commenced until all the piles had been screwed, owing to the floating crane being required for both operations. The abutments were constructed at the same time and independently of the other work on the job.

Personnel.

Messrs. Braithwaites sent from India the following personnel:-

One British Engineer-in-charge.
One British Engineer.
Two Indian Engineers.
One Indian Clerk.
56 Indian workmen (Including gangers and cooks).

These arrived at site in August and September, 1941. An Egyptian time-clerk was engaged locally. Egyptian labour was obtained through P & L.

At the end of December, 33 Indian riveters arrived from India. This was four months before they were actually required, and these men were employed on other jobs in the meantime. They were loaned to D. of W. for a short time, but transport arrangements broke down.

In January 1942, the E.S.R. loaned 3 Egyptian engineers and a gang of semi-skilled labourers.

The army appointed a construction liaison officer and two local acting unpaid corporals (one clerk and one inspector).

Braithwaites' British staff were paid their full Indian salaries. The Indian Staff and workmen were paid approximately twice their normal rates in India. The Egyptian Engineers were paid their normal rates plus an allowance for expenses. Egyptian labour was generally paid at rates fixed by P & L. The gang loaned by the E.S.R. was paid at rates recommended by them.

The Indian personnel comprised Hindus and Muslims.

Preparation

A camp was constructed in September, 1941, by 2 Aust. Fly Constr Coy R.A.E.

Site work commenced at the end of September 1941. A bund was constructed on the Africa bank and a 15-ton Scotch derrick mounted on bogeys and rails was erected on it. This derrick commanded the site of all the piles and superstructure on the Africa side.

The screwing cage and plant was erected on flat steel pontoons, and 50 cwt anchors were laid to the north and south to form the anchorage for screwing. Preparations for screwing were complete by Dec. 15.

A 10-ton scotch derrick was erected on pontoons for the work on the Asia side.

Screwing Cylinder Piles

The piles were screwed with Braithwaites' patent electric capstan (2 motors 30 HP) assisted by a 4" air lift pump for evacuating the soil from the centre.

The capstan was anchored by a steel wire rope 1¼" dia. which passed through the capstan and was secured to 50 cwt anchors laid on the canal bed to the north and south. These proved inadequate, and were supplemented by "dead men" composed of tiers of pile cylinders on the canal bank. Adjustment of the line of the anchor cable was obtained by winches and tackles pulling on kedge anchors.

Screwing Cylinder Piles (cont'd)

The piles were held in position by a steel framework mounted on barges. They were also held by wire rope guys, but canal traffic prohibited the use of guys in the direction of the centre of the canal. The guide cage was made to take two piles at the same time.

The cylinders and screws were assembled and bolted up on the Africa bund. The piles on the Africa side were lifted straight into position by the 15-ton crane. Those on the Asia side were floated across on a cradle suspended from two native barges, and then handled by the 10-ton floating crane.

The first cylinder was pitched on 16th Dec., one of the fender piles adjacent to the Africa pivot pier being the first. After four days screwing, only four feet penetration had been obtained. This was partly due to a thin bend of hard clay and partly to the difficulty of keeping the cylinder in position on the sloping bank of the canal. The slope was an average of 1 in 2 and very irregular.

By the ninth day, the pile had been screwed to R.L. - 12. Messrs. Braithwaites originally proposed to found the pivot pier at R.L. -21 feet. They now requested permission to found at R.L. -3 ft. The D.D.Tn Construction and Asst. Chief Engineer (Bridges) R.S.R. agreed to found the piles at R.L. -12 feet.

To prevent the piles from wandering in the initial stages, Messrs. Braithwaites' engineer devised a pilot tube, which was constructed at site with the aid of welders loaned by 2 Aust. Ely Constr Coy. This was an octagonal steel tube, 22" across the flat, which projected from inside the cylinder 5 feet below the screw at the start, and turned with the pile. A mechanism was provided so that it could be released from above, and then withdrawn when the screw had passed below it. This tube was ready on 21 Jan., by which time six piles had been screwed. It was used in all subsequent piles, and proved to be of great value.

The screwing of the cylinders on the Africa side was completed on 10 March, after 85 days work.

To improve penetration through the belt of hard clay, a pumping set capable of delivering 100 gals/min. against 300 feet head was obtained from D.D.W.(S). This set was installed in time to operate on the Asia side. Its function was to provide a powerful jet to break up the soil under the screw, and it was used in addition to a 3 throw 4" x 6" reciprocating pump normally used by Braithwaites with the air lift.

Screwing of the first Asia pile proceeded as expected, until the screw was about four feet from the final level. A very hard strata, apparently sandstone was encountered here. Cutting off the tops of the cylinders was considered, but it was decided that this would cause too much delay. Enquiries were made for shorter cylinder lengths to be cast in Egypt, but a satisfactory guarantee of delivery and quality could not be obtained. It was therefore decided to screw the piles down through this hard strata, and this was done, taking an average of 10 hours for the last four feet of each pile.

Screwing of the cylinders on the Asia side was finished on 28th May, 164 days after the commencement of screwing. The average time per pile was, therefore, just under 3¼ days, including time for shifting plant.

Messrs. Braithwaites were continually urged to work a night-shift on screwing the piles, but they maintained that the operation was too difficult to carry out at night. There were no lighting restrictions.

Filling Cylinder Piles.

When the screwing plant had been moved sufficiently away from a screwed cylinder, the cylinder was filled with sand to 15 feet below the canal bed at that point, and then plugged with concrete. The first plugs were made by lowering concrete in bags. These nearly all failed when the cylinder was pumped out. Various methods of lowering concrete through the water were tried, including bottom opening bags and finally a bottom opening skip, which functioned satisfactorily. The plugs were located at a flange to make a key with the cylinder, and were 2 to 3 feet thick.

Tests made on concrete blocks set under salt water disclosed the interesting fact that after 3 days, blocks made with ordinary cement were stronger that blocks made with rapid hardening cement.

After plugging, the cylinders were filled with concrete to within 3 feet of the top.

Pivot
Slab.

Shuttering for the pivot pier slabs was carried on a framework of steel joists suspended by bolts from the top flanges of the cylinders. (The top lengths of the cylinders were cast with an external flange for this purpose). The slabs were cast in two portions, a horizontal construction joint being made at the centre.

tables.

Erection of the Africa turntable was very slow, largely owing to the contractors' best men being concentrated on the pile screwing. The roller paths of both turntables were levelled with the greatest of care to less than 1/32".

table
lwork.

The drum girders and the internal girders were erected on jacks, and then s lowered on to the turntable. The webs and top flanges were riveted and the whole jacked up to permit rivetting of the lower flange plates. The steelwork was then lowered and centred accurately on the pivot pin, and the holes connecting it to turntable drilled. It then had to be jacked up again for rivetting the ma upper turntable plate to the drum girder, and finally lowered again and bolted to the turntable.

l
rstructure.

Falsework consisting of strengthened Hamilton Bridges was erected spanning between the fender and dolphin piles.

The steelwork had been pre-distorted in fabrication in accordance with normal modern practice. That is, the members were fabricated to lengths such that they would assume their geometric lengths when fully stressed, whilst the joints were fabricated to their correct geometric angles.

The bottom chords and floor steelwork were erected on jacks standing upon the Hamilton span falsework with the bottom chord horizontal, and riveted. The web members were erected and riveted at the bottom ends only. The top chords were erected on cleats on the verticals, and the joints riveted.

The calculated camber was then jacked into the span, and erection and rivetting completed.

The object of the pre-distortion in fabrication and this method of erection is to reduce the secondary stresses to a minimum when the steelwork is carrying its maximum primary stresses.

The span was erected with the vertical at the pivot centre truly vertical. When the timber deck had all been placed in position, the span was balanced by adding weights at the end until the steelwork commenced to lift at the opposite point of support. This was determined by inserting feeler gauges. By observing the difference between the weights at each end, it was possible to compute the weight required for exact balance. Further weights at the ends were then added to bring the end of the span to the levels required at the abutment.

With the vertical at the pivot centre truly vertical the anchor end of the span was 3" higher than the span at the pivot pier. There was some discussion as how to avoid undue distortion of the steelwork and to obtain equal loading at the pivot piers, and eventually it was decided to load the end so that the anchor end of the span was 1" above the span at the pivot pier when the bridge was "made".

A point noticed on the steelwork was that it was necessary to do a certain amount of rivetting before erection could be completed. This caused delay in progress.

The erection of the Africa span took six weeks, whilst the Asia span took four weeks. The slowness of the former was due to the contractors' best men being employed on screwing cylinders on the Asia side, and also to the crane being frequently required for assembling cylinders.

The camber of the Asia span proved to be $\frac{3}{4}$" higher than that of the Africa span, so that it was necessary at the end to raise the level at the Asia abutment by a corresponding amount.

imber Deck.

Difficulty was met in keeping the 12" x 6" longitudinal timbers down, Messrs. Braithwaites' detail showed 8" nails, which were considered unsatisfactory. Tn. Stores manufactured a quantity of 9" spikes, but these were not entirely satisfactory, and it was decided to supplement these with one bolt at each end of each timber.

achinery.

This was erected with great care, and worked very well when finished. Erection was very slow.

utments.

The excavation was made without timbering. Messrs. Braithwaites made no provision for pumps, and did not indent for a pump until work could proceed no further. Fortunately the demand had been anticipated, and a pump was obtained within two days.

The abutment was designed with a reinforced concrete toe. The fixing of reinforcement in the base, with water springing out of the floor was difficult, and a stepped footing of standard design without reinforcement would have been more satisfactory.

In the Africa abutment, this R.C. toe was not constructed to the satisfaction of the construction liaison officer. A step 2'-0" wide was, therefore, constructed above it, in order to relieve the stress in the toe.

lphins.

The dolphins as designed by the E.S.R. and Messrs. Braithwaites consisted of a triangular R.C. slab carried on three screw cylinder piles. The slab projected about three feet beyond the end of the span in the "cut" position, and its edge was at right angles to the line of the canal.

In June 1942, it was decided to provide a taper nose to the dolphins involving the use of an additional cylinder pile. By founding the main piles 9 feet above the design level, a reserve of C.I. cylinders had been accumulated, but no extra screws were available. Piles 72 ft long, consisting of six C.I. cylinders bolted together were sunk 25 ft into the ground by evacuating the soil with an airlift. This was wholly successful and in only one case was difficulty encountered. The other piles were sunk in about six hours each.

It was found necessary to change the top cylinder length of one of the original piles of the north Asia dolphin. This was done by pumping the water out to below the first flange and inserting long bolts in this flange. The cylinder was then unbolted and slid up over these bolts, and the new cylinder slid down over these bolts. In this particular case, the water was evacuated by the airlift before the pile had been plugged. The suction of the airlift caused a settlement of one foot. The pile was plugged with a 10 foot deep plug, and an attempt was made to screw it further. The capstan, however, was unable to turn the pile.

uflage.

The whole of the structure over the canal, including the pivot pier and dolphins, was painted dark grey. The timber deck was creosoted to a dark colour.

The abutments and anchor steelwork were painted light stone colour.

fications
ditions.

As well as the modifications already mentioned, the following additions were made at site:-

(1) Spring buffers at the dolphins to stop the spans in the "cut" position.
(2) Locking bolts to lock the spans in the "cut" position.
(3) Guide pins and grooves in the wedges to locate the spans at the abutments.
(4) Navigation lamps, made by Tn. Stores.
(5) Stabilising girders to the spans at the pivot piers. On the Africa side, these comprised joists spanning between the trusses and bearing on the drum girder. On the Asia side, girdgrs were erected spanning between the trusses and carrying wheels which ran on a rail on the pivot pier. The object of these girders was to provide extra stability for the span during rotation. Suitable clearances were left, so that these additional girders did not take any load when the bridge was "made".

odifications & additions. cont'd.

(6) Underwater bracing to all the dolphin piles. This was made of heavy steel joists (24" x 7½") and steel plate clamps.

(7) It was found that the wheels on the stabilising brackets at the Asia turntable would not rotate when the span was swung. The wheels were machined to a conical form, and the result was satisfactory.

Tests.

Tests with a loaded train corresponding to the design load were carri out by the E.S.R. on August 3rd and 4th, 1942.

The tests were entirely satisfactory, and the maximum deflection recorded was 2⅜".

Date of Completion.

Messrs. Braithwaites estimated that they could complete the bridge in 10 months from the date of the order, 15th May, 1941. This put the provisional finishing date at 15 March, 1942.

The bridge was handed over to the E.S.R. for testing in an unfinished condition on 4th August, 1942.

This represents a delay of 4½ months brought about as follows:-

(1) In July 1941, it was decided to construct the bridge at Firdan, and not at Kantara as originally projected. This entailed alterations to the erection scheme and plant required. The ground at Firdan eventually proved harder then indicated by the borings made at Kantara.

(2) The first two shipments were delayed en route and arrived at site a month after they could have been reasonably expected.

(3) Pontoons ordered from E.S.R. were delivered on an average a month late. Owing to the change of site, the arrangement of floating plant was worked out at site, and this was held up.

(4) The plant at first gave considerable trouble.

The net result of these four points was that the pile screwing commen ed 1½ months after the estimated date.

(5) Messrs. Braithwaites seemed to be unprepared for screwing under the conditions prevailing at Firdan.

Except for the sandstone encountered at R.L. 7 ft on the East bank, the soil was no harder than might normally be expected in Egypt. The first pile took nearly nine days to screw, and the total time for screwing 44 piles, was 5½ months instead of 2½ months estimated.

Messrs. Braithwaites had made no provision in their staff for contingencies, such as difficult screwing. The result was that their only experienced foreman had to devote six months entirely to screwing piles, to the detriment of other work.

(6) In order to get rail traffic operating at the earliest possible date, work not having an immediate bearing on this, such as the dolphins, was neglected. This work was not finished until November.

CONCLUSION

General

A railway bridge of novel design has been constructed across a major waterway, without interruption of the water-borne traffic, and put into operation 15 months after the order was placed with the contractor. The actual construction occupied 13 months, including three months work after the bridge was put into operation.

This was done in a foreign country in war-time, subject to the inherent handicaps of war conditions.

Design.

The project was carried out without the assistance of a firm of consulting engineers, technical advice being provided by the bridges dept., of the E.S.R.

A boring was made at Firdan. The exact location was not recorded, and the levels of the strata were related to the canal bed at the point of boring without reference to a bench mark. There is no record of the time taken to pass through the various strata, nor evidence of any experienced engineers being present during the boring. Much of the value of this boring was lost on this account. Appendix 1 shows a comparison of the boring record with a record of the soil raised by the air-lift during the screwing of a cylinder adjacent to the point of boring, the initial level of the strata from the boring having been guessed.

The cylinders were screwed in firm soil, in deep water from floating craft. Canal traffic restricted the guys on the cylinders to three ways, and the cylinders were located on an irregular slope of 1 in 2. All this information was available when this type of foundation was decided upon. There is no record of cylinders of these dimensions having been screwed under similar conditions before. A large amount of heavy and specialised plant is required for screw cylinders piles of these dimensions, and a great amount of preperation. The result was that driving of the piles was not commenced until 16 Dec. 1941.

No serious accidents occurred, but a mishap to any of the special plant such as the capstan or the heavy cranes would have caused very considerable delay.

More common types of foundations might have taken as long as the 5½ months required to drive the screw cylinders, but by utilising materials and plant available in Egypt, the foundations could have been completed by the end of 1941. The sinking of the extra dolphin cylinders, and the subsidence of one dolphin cylinder indicated that R.C. open caissons could have been sunk rapidly to a firm foundation.

Fabrication & Delivery.

The steelwork deliveries were completed early in February, 1942. The fabrication and marking was excellent, and the steelwork went together without difficulty.

Works at Site

Messrs. Braithwaites' work at site was of high quality. The progress of some parts of the work was slow, and an excessive number of men were used. This was largely due to inadequate supervision, the lack of an experienced general foreman and of a plant foreman being particularly noticeable.

The layout of the yard was very poor, the camp being situated between the stores and the job, and the offloading berths being beyond that. This entailed a lot of unnecessary carrying of materials.

All the specialist processes such as the anchorages for screwing, the actual screwing of the piles, and the plugging of the cylinders were unsuccessful at first, and was achieved by trial and error.

A number of minor hitches and mistakes occurred which were nearly all due to insufficient experienced supervision. In general, however, the operations were carried out expeditiously.

W.D. staff.

The W.D. staff was largely occupied in obtaining stores at very short notice. An N.C.O. experienced in stores would have been an asset.

The Indian engineer-foreman, M. GHUR, who was in charge of the screwing of the piles, worked with a minimum of supervision, and merits the highest praise. He worked extremely long hours and rarely had a day off. The credit for the completion of the screwing in 5½ months, and not in a much longer period, is mostly due to him.

Also worthy of special mention, is the Egyptian Engineer, AHMED MUKHTAR, who was in charge of most of the concreting work.

Particular assistance was rendered by 125 E & M Coy., R.E., which executed all forms of repairs and made a number of accessories both for the permanent structure and the special plant.

No. 1 R.E. Workshops (Special) was also of great assistance in issuing tools and making accessories.

Capt. R.E.
Construction Liaison Officer (Bridging).

27 Oct 42.

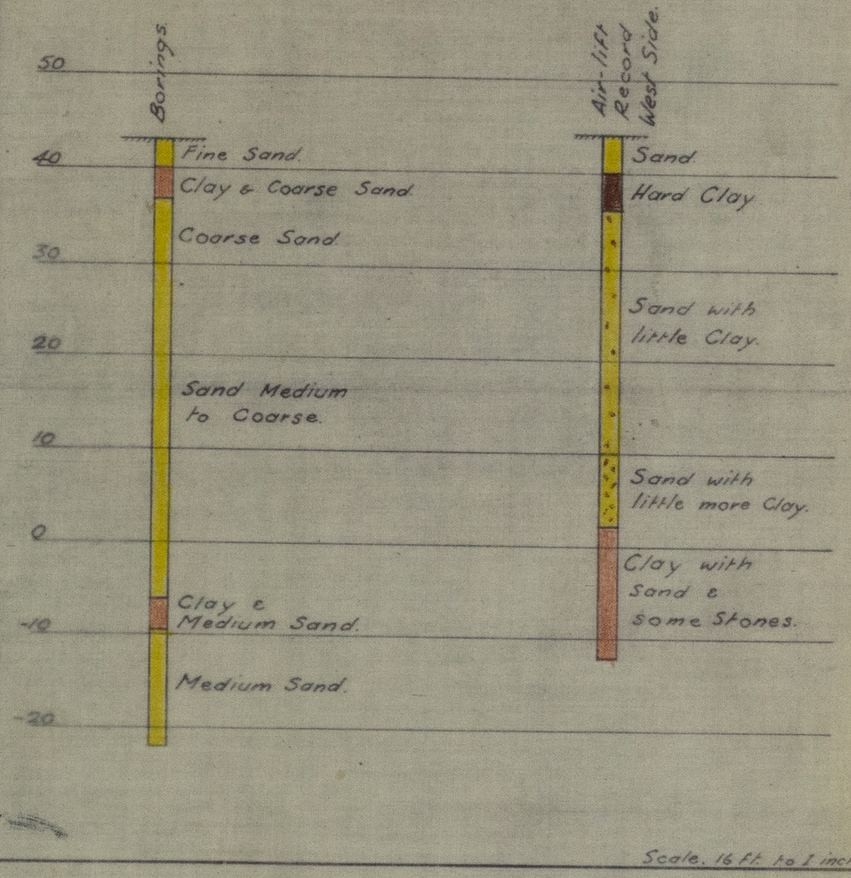
Scale. 16 Ft. to 1 inch.

DOLPHINS SCREW CYLINDERS	
PLUG & CONCRETE	
CONCRETE CAPS.	
TRANSFER FALSEWORK FROM AFRICA SIDE.	
ECT ASIA TURNTABLE AND TURNTABLE STEELWORK	
ECT ASIA SUPERSTRUCTURE	
VET " "	
MANTLE ASIA FALSEWORK	
ECT ASIA TURNING GEAR.	
Y TIMBER DECKING AND RAILS	
NSTRUCT ASIA ABUTMENT.	
ECT ANCHOR STEELWORK D WEDGING GEAR.	
INT STEELWORK.	
ECT FENDER TIMBER.	
MANTLE PLANT & CLEAR SITE.	
ACE DOLPHIN PILES.	

DRG. NO. TN. 8,538

APPENDIX I.

Comparison of Borings taken approximately on centre of Africa Pier with the record of soil expelled by the air-lift during screwing of cylinder WP1 & WP2.



Scale. 16 ft. to 1 inch.

SIA DOLPHINS	
SCREW CYLINDERS	
PLUG & CONCRETE	
CONCRETE CAPS.	
TRANSFER FALSEWORK FROM AFRICA SIDE.	
RECT ASIA TURNTABLE AND TURNTABLE STEELWORK	
RECT ASIA SUPERSTRUCTURE.	
VET " "	
SMANTLE ASIA FALSEWORK	
RECT ASIA TURNING GEAR.	
Y TIMBER DECKING AND RAILS	
ONSTRUCT ASIA ABUTMENT.	
RECT ANCHOR STEELWORK ND WEDGING GEAR.	
AINT STEELWORK.	
RECT FENDER TIMBER.	
SMANTLE PLANT & CLEAR SITE.	
ACE DOLPHIN PILES.	

DRG. NO. TN. 8,538

TN. CONSTRUCTION (TN3) SUEZ CANAL BRIDGE. PROGRESS RECORD. **APPENDIX 2.**

	41 SEPT.	OCT.	NOV.	DEC.	42 JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
UT OF YARD AND CAMP AND STRUCTION OF BUND																
OADING, ERECTING AND EMBLING PLANT.																
ICAN PIVOT PIER SCREW CYLINDERS																
PLUG & CONCRETE																
CONCRETE CAP																
ICAN DOLPHINS SCREW CYLINDERS																
PLUG & CONCRETE																
CONCRETE CAPS																
ECT AFRICA FALSEWORK																
CT AFRICA TURNTABLE & TURNTABLE STEELWORK.																
ECT AFRICA SUPERSTRUCTURE																
ET " "																
CT " TURNING GEAR.																
TIMBER DECKING & RAILS.																
STRUCT AFRICA ABUTMENT.																
CT ANCHOR STEELWORK AND WEDGING GEAR.																
ECT CENTRE LATCH PINS																
A PIVOT PIER. SCREW CYLINDERS																
PLUG & CONCRETE																
CONCRETE CAPS																
A DOLPHINS SCREW CYLINDERS																
PLUG & CONCRETE																
CONCRETE CAPS.																
RANSFER FALSEWORK FROM AFRICA SIDE.																
ECT ASIA TURNTABLE AND TURNTABLE STEELWORK.																
ECT ASIA SUPERSTRUCTURE.																
VET " "																
MANTLE ASIA FALSEWORK																
ECT ASIA TURNING GEAR.																
Y TIMBER DECKING AND RAILS																
NSTRUCT ASIA ABUTMENT.																
ECT ANCHOR STEELWORK D WEDGING GEAR.																
INT STEELWORK.																
ECT FENDER TIMBER.																
MANTLE PLANT & CLEAR SITE.																
ACE DOLPHIN PILES.																

OPENED TO RAIL TRAFFIC 7 AUG 42

Appendix 3.

Schedule of Quantities.

C.S. Turntables.	tons	134 +
C.I. Cylinders and screws	tons	909
M.S. in turntable steelwork	tons	46
M.S. in superstructure.	tons	669
M.S. in anchorages.	tons	16
Miscellaneous permanent steelwork	tons	31
Temporary steelwork supplied by Braithwaites	tons	109 *
	"	1,914.

Concrete 1:2:4 mix.

In abutments	cu. yds	790
In cylinders	cu. yds	455
In pivot pier caps.	cu. yds	340
In dolphin slabs	cu. yds	500
	"	2,085

M.S. Reinforcements.

In abutments	tons	16
In pivot pier caps		37
In dolphin slabs		65
		118

Timber.

In deck	Cu. ft	7500
In fenders	cu. ft	2100
		9600

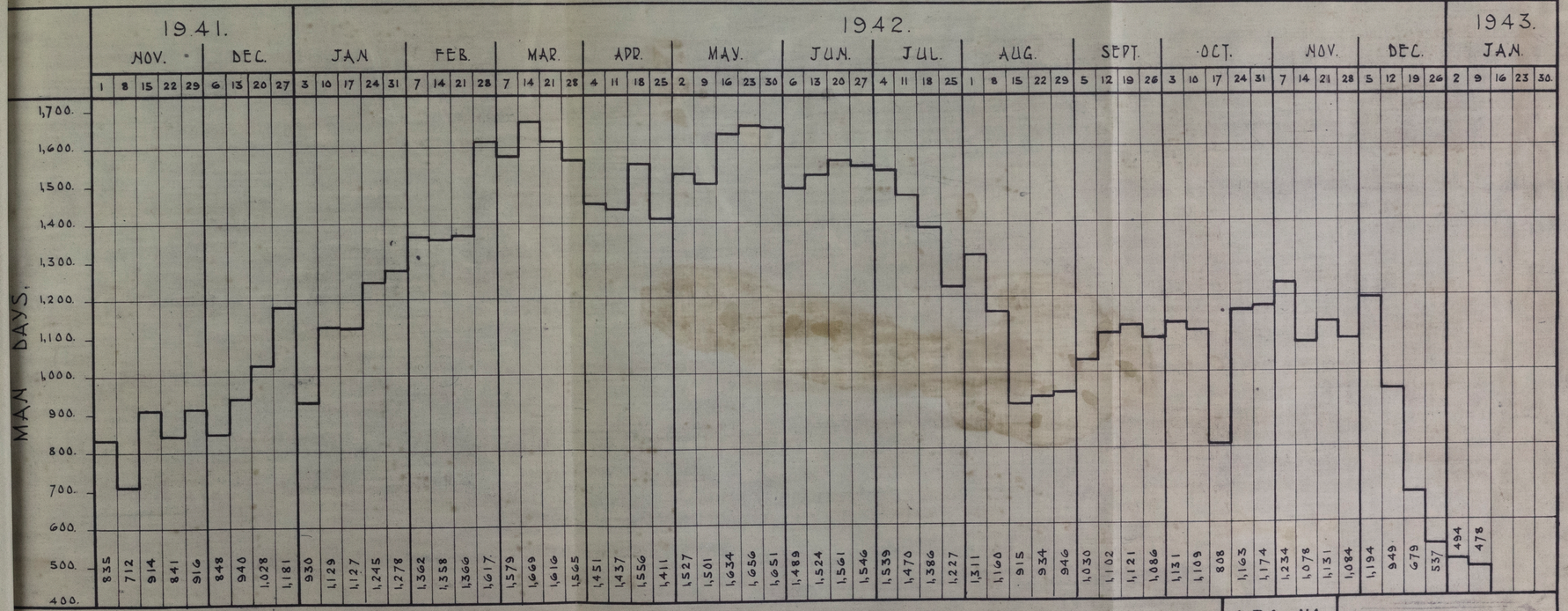
* Two 100 ft Hamilton bridges and two 110 ft Hamilton bridges were supplied as additional temporary steelwork by W.D.

\+ Includes spare segments and the turning gear.

SUEZ CANAL BRIDGE. EL FIRDAN.

APPENDIX. 4.

RECORD OF LABOUR EMPLOYED.



NOTE :- NORMAL WORKING DAY, 9 HRS.

DRG. NO. TN. 8539.

JOB NO. 203.

TRANSPORTATION DIRECTORATE
TN.8539 FEB '43.
R.A. NIGHTINGALE SPR.

removing guide plates etc. was, however, due to the stiffness of the ground and would not have been so great for softer ground.

Appendix 5.

TYPICAL RECORD OF SCREWING CYLINDERS.

Cylinders WP7 and 8 were completed in a gross time of 4 days 9 hours. The average time worked each day was 12 hours.

The following is a schedule of how the time was spent:-

Monday.	09.00 to 16.00	Moving pontoons to position.
	16.00 to 19.00	Pitching cylinder WP8.
Tuesday.	06.00 to 07.00	Assembling cylinder WP7.
	07.00 to 1300	Screwing WP8. 8 feet.
	13.00 to 14.30	Removing pilot tube and adding cylinder.
	14.30 to 16.45	Screwing cylinder WP8. 7 feet.
	16.45 to 18.15	Adding Cylinder to WP8.
	18.15 to 19.00	Screwing WP8. 9 feet.
Wednesday	06.00 to 13.10	Assembling pilot tube in WP7 jetting canal bed and pitching WP7.
	13.10 to 13.45	Screwing WP7. 8 feet.
	13.45 to 15.10	Removing pilot tube and adding cylinder, to WP7.
	15.10 to 16.07	Screwing WP7. 7 feet.
	16.07 to 18.05	Adding cylinder to WP7.
	18.05 to 18.30	Screwing WP7. 9 feet.
	18.30 to 19.45	Adding cylinder to WP8.
Thursday	06.00 to 07.40	Crane occupied plugging cylinders.
	07.40 to 08.45	Putting capstan and air lift on WP8.
	08.45 to 09.25	Screwing WP8. 9 feet.
	09.25 to 11.00	Transferring capstan and air lift to WP7.
	11.00 to 11.40	Screwing WP7. 9 feet.
	11.40 to 15.00	Adding cylinder to WP8 and transferring capstan and air lift.
	15.00 to 17.00	Screwing WP8. 9 feet (air lift jamming)
	17.00 to 19.00	Adding cylinder to WP7.
Friday.	06.00 to 08.40	Plugging cylinders
	08.40 to 09.10	Screwing cylinder WP7. 1 foot.
	09.10 to 10.10	Plant breakdown.
	10.10 to 10.55	Screwing cylinder WP7. 8 feet.
	10.55 to 13.50	Removing guide plate, adding cylinder & transferring capstan etc. to WP8.
	13.50 to 14.15	Screwing cylinder WP8. 2 feet.
	14.15 to 16.35	Removing guide plate, adding cylinder and transferring capstan etc. to WP WP7.
	16.35 to 16.40	Screwing cylinder WP7. 2 feet 6 ins.

The above record analyses as follows:-

Moving pontoons and pitching	18	hours.
Adding cylinders and transferring plant	21	"
Screwing and Air-lifting	16	"
Plant Breakdowns	1	"
	56	"

On the mornings of Thursday and Friday, 4½ hours were lost plugging cylinders. It was intended that this should be done when the crane was not occupied, but in fact this did not fit in. A gyn has now been rigged for plugging, and this should not occur again.

Screwing was carried out satisfactorily by the artificial light on two evenings. The whole operation is controlled by one Indian Engineer-foreman, who is working over 12 hours per day. The gangs each worked 11 hours, thus overlapping for 10 hours. They were not all necessarily employed on screwing all the time. There are no organised shifts.

The time for moving pontoons was excessive. There was a strong wind blowing, and the operation was not skilfully performed.

The time occupied by screwing the last 9 feet was not excessive. The time spent in removing guide plates etc. was, however, due to the stiffness of the ground and would not have been so great for softer ground.

Job 203 (Braithwaites)
El Firdan.

List of Plant Materials Used on Job 203.

Winches, hand	12 Nos.
Derrick poles, timber	4 Nos.
Pulley blocks, single sheave	3 Nos.
Pulley blocks, two sheaves	4 Nos.
Pulley blocks, three sheave	2 Nos.
Wire rope, book slings	2 Nos.
Jacks, mechanical	4 Nos.
S.W.R. slings	12 Nos.
S.W.R. various sizes	23 lengths
S.W.R. slings	13 Nos.
Pumping set 5" x 4"	1 No.
Southern cross pumping set and suction	1 No.
Chains	6 Nos.
Anchors	6 Nos.
Shackles	24 Nos.
Buoys with chains and shackles	4 Nos.
Shovels	152 Nos.
Picks	6 Nos.
Fasses	12 Nos.
Concrete pans	36 Nos.
Hammers	37 Nos.
Jigger Auger male	7 Nos.
Blow lamp	1 No.
Saws crosscut	4 Nos.
Chests, carpenters	2 Nos.
G.I. Piping	335 lin ft
G.I. bends, flanges and reducing sockets	80 Nos.
Steel rule 2 ft	2 Nos.
Steel tape 100 ft	1 No.
Tee square	1 No.
Steel tape 50 ft	2 Nos.
Staff, levelling	1 No.
Pontoons	7 Nos.
Concrete mixers	2 Nos.
Hamilton bridges	4 Nos.
Spanners, rat tailed	36 Nos.
Spanners, box	2 Nos.
Spanners platelayers	8 Nos.
Voltmeter o-500	1 No.
Compressors, I.R.	2 Nos.
Pneumatic chain saw	1 No.
Forges rivetting	4 Nos.
Machines, wood boring	2 Nos.
Auger bits, various sizes	44 Nos.
Feeders Oil, Easyest	3 Nos.
Covers, waterproof	8 Nos.
Sculls 10 ft	4 Nos.
Gravel Screen	1 No.
Files, various sizes	19 Nos.
Cylinders, compressed gas	5 Nos.
Decauville track	600 lin ft.
Decaucille Bogies	4 Nos.
Standard gauge track and fittings	600 lin ft.

Job 203 (Braithwaites)
El Firdan.

Plant Materials Supplied by Braithwaites.

Pulley Blocks	21 Nos.
Snatch Blocks	6 Nos.
Bottle Jacks	2 Nos.
S.W.R. Various sizes	26 Nos.
Wire clamps	16 Nos.
Shackles	17 Nos.
Chains	6 Nos.
Shovels square nose	1 No.
Fasses	2 Nos.
Hammers	34 Nos.
Wooden mallet	1 No.
Wood augar	1 No.
Revolution counter	1 No.
Pliers	26 Prs.
Auger bits	8 Nos.
Crowbars	6 Nos.
Vices	2 Nos.
Pipe wrenches	2 Nos.
Drills	8 Nos.
Rivetting tongs	6 Nos.
Screw drivers	6 Nos.
Spanners rat tailed	84 Nos.
Spanners, single ended	4 Nos.
Spanners, box	20 No.s
Spanners adjustable	4 Nos.
Voltmeter	1 No.
Cable	400 Yds.
Rubber gloves	1 Pr.
Insulated screw driver	1 No.
do Pliers	1 No.
Forges	7 Nos.
Pneumatic chisels blank nose	6 Nos.
Tarpaulins	4 Nos.
Oil Cans	4 Nos.
Files various sizes	13 Nos.
Tanks water	4 Nos.
Blacksmith anvil	1 No.

Job 203 (Braithwaites)
El Firdan.

Appendix 7.

Use and Waste materials Used on Job 203.

Gravel	2,500	cu cm.
Grease	371	lbs.
Diesel Oil	1,964	Galls
Cement	630	tons
Coal	496	tons
Coke	18	tons
Camouflage	367	lbs
Packing case timber for shuttering	91	tons
Biscinfectants	66	Galls
Paint	5,705	lbs.
Brushes, paint	28	Nos.
Brushes, wire	15	Nos.
Nails	1	ton
Screws	138	doz.
Lubricating Oil	474	Galls.
Putty	56	lbs.
Rubber Insertion	72	lbs.
Native earth baskets	1,800	Nos.
Padlocks and keys	14	Nos.
Emery Cloth	150	sheets
T Hinges	18	Nos.
G.1 Sheets	286	Nos.
Linseed Oil	30	Galls.
Turpentine	8	Galls.
Asbastos rope	102	lbs.
Cotton Waste	7	cwt.
Sandbags	3,000	Nos.
Welding rods	12,000	Nos.
Hose piping	94	feet
Staufer lubricators	10	doz.
Binding wire	3,000	lbs.
Hacksaw blades	18	doz.
Timber spikes	9	cwts.
Solder	2	lbs.
Waste oil	200	Galls.

APPENDIX 8.

E.S.R. Engineering Department.

TEST OF EL-FIRDAN BRIDGE.

The test was carried out on the 3rd and 4th August 1942.

On the first day a train composed of two locomotives weighing 93 tons & 127 tons and 6 hungarian 30 ton wagons was used. On the second day two locomotives of 127 tons without wagons were applied.

Deflections were measured at the central latch and the quarters of the middle span as well as the centres of the side spans.

The maximum measured deflection at the central latch under the effect of the two locomotives amounted to 60 mms. In general the measured deflections are 66% of the corresponding calculated values.

Levelling before and after the test has shown no change in the bridge.

The measured stresses conform completely with the calculated values.

The deflection of the cross girders on the drums are directed downwards and that means NO HAGGERING.

The measured times for wedging and unwedging with two men at each wedge are : Asia side 3.30 & 3.30 minutes respectively.
Africa side 4.30 & 3.30 " "

The measured times for turning the bridge with 6 men at one arm of the key are :-

5'-15" for the Africa side span

& 3'15" " " Asia " "

Conclusion.

Test results are satisfactory and the bridge was opened to traffic on the 7th August 1942.

WEIGHTS & REACTIONS OF BRIDGE.

Total weight of Steel work in Superstructure (exclusive of Turntables)	542 Tons
Total unloaded reaction on each main pier	358 Tons
Total maximum loaded reactions on Abutment	167 Tons down
or	151 Tons up
Pier	834 Tons down
Central Catelpins	63 Tons up or down

COPY.

15.9.42

EGYPTIAN STATE RAILWAYS.

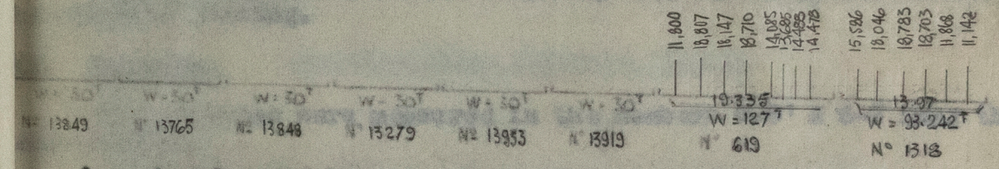
ENGINEERING DEPARTMENT.
(BRIDGES)

P.V. of Loading Test of El-Firdan Swing Bridge over Suez Canal on 3rd & 4/8/42.

Test was carried out according to the programme previously made (copy herewith).

LOADING TEST.

The loading test was carried out on the 3rd & 4th August 1942. On the first day the load was composed as shown hereunder :-



i.e. two locomotives and six hungarian wagons.
On the second day the test was continued with the same two locomotives without wagons.

Deflections.

The measured deflections in m/ms are as tabulated hereunder :-

LOAD	Latch M1 f	Latch M1 =	Latch M2 f	Latch M2 =	Latch M3 f	Latch M3 =	Latch M4 f	Latch M4 =	Latch M5 f	Latch M5 =	Remarks
2 Locomotives - 6 Hungarian 30 T. Trucks.											
Static Load	-	-	14 13.8	1 1.2	38.8	1.2	31.2	-	-	-	
15 Km/h Sp.	5.2	2.4	15.2	-	37.6 39.6	- -	31.2	-	-	-	
20 " "	6.0	2.0	14.8	-	38	1.6	30	2	-	-	
25 " "	7.2	1.2	14.4	1	40	-	33.2	0.8	-	-	
30 " "	6.0	2.4	15.6	1.2	40.8	-	31.6	0.8	-	-	
2 Locomotives.											
Static Load	-	-	30.4	1.6	60	3.2	32	2	-	-	
15 Km/h Sp.	-	-	30.4	1.2	60	3.2	33.6	-	-	-	
20 " "	-	-	30	1.6	58.8	2	31.6	2	-	-	
25 " "	-	-	30	2	59.2	2	31.6	2	-	-	
30 " "	-	-	30	1.4	60	2	32	2	-	-	

Maximum measured and calculated deflections under static load the latch are shown hereunder :-

Kind of Load	Maximum measured deflection M	Maximum calculated deflection C	Ratio M : C
2 Locomotives 6 Wagons	38.8	61.0	64%
Two locomotives only	60	87	69%

%

II. **Levelling.**

The bridge was loaded some days before the test by the passage of locomotives No. 554 (T). The permament settlements could not therefore be measured.

Levelling was made before and after the test for bridge open and closed.

Results are shown on the attached table.

The differences of levels of the main points after the wedging operation are insignificant except at points 10 & 11, where a difference of 10 mms. appears this may be due to the adjustment effect of the latch getting the two ends of the spans level.

Measured deflection lines fixed by the levelling are shown on the attached drawing.

III. **Stresses.**

The stresses were measured in the members 9-8' & 6-7 near the panel points.

In these members the maximum stress measured and calculated is shown hereunder :-

member	measured stress.	Calculated Stress.
9-8'	440	450
6-7		
Up	- 50	- 70
Down	- 470	- 490

IV. **Deformation of the Central Cross Girders.**

Deflections of the main cross girders of the drums were measured. At the big drum two instruments were placed under the intersection of the upper drum, girders and the main cross girders (south side)

The deflections under static load	=	0.82 & 0.89 mms.
The corresponding calculated values are		0.85 & 0.95 "
The values measured at maximum speed attained during test are		1.1 & 1.2 "

All deflections are downwards i.e. no hammering.

V. **Rotation of the support on drum.**

Angle of rotation measured at the bottom chord at the central support of the big drum amounted to

The corresponding calculated value is 105"

VI. **TIME OF OPERATION.**

The measured time of operation is tabulated hereunder :-

Operation	Africa Side M. Sec.	Asia Side M. Sec.	Remarks
Closing bridge	5 15	2 15	6 men at one arm only
Opening bridge	5 00	5 00	4 men
Wedging	4 30	3 30	2 "
Unwedging	3 30	3 30	2 "

The calculated time for opening or closing the bridge by 3 men at each arm of the key is:

Africa Side	6 minutes
Asia Side	4 "

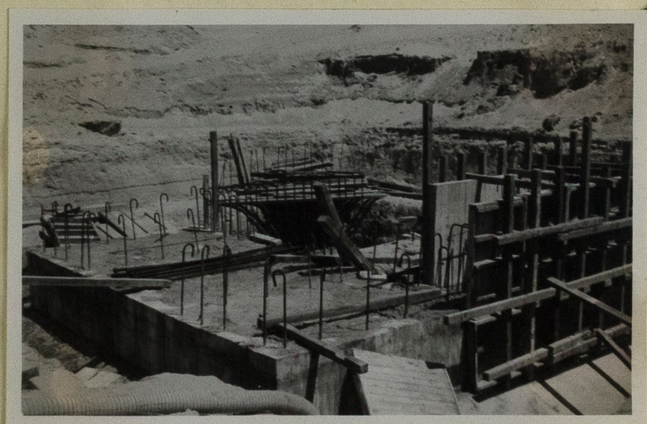
Sgd/ ?--



Concreting Africa Abutment - 15.11.41.



Concreting Africa Abutment - 19.11.41.



Fixing shuttering for Africa Abutment
Wing Walls - 24.11.41.

Levelling.

The bridge was loaded some days before the test by the passage
locomotive No. 554 (T). The permanent settlements could not
efore be measured.

Levelling was made before and after the test for bridge open and
ed.

Results are shown on the attached table.

The differences of levels of the main points after the wedging
ration are insignificant except at points 10 & 11, where a dif-
ence of 10 mms. appears this may be due to the adjustment effect of
latch getting the two ends of the open level.

Measured deflection lines fixed by the levelling are shown on
attached drawing.

Stresses.

The stresses were measured in the members 8-8' & 8-7 near the
l points.

In these members the maximum stress measured and calculated is
wn hereunder :-

Member	measured stress.	Calculated Stresses.
8-8'	-410	-480
8-7		
Up	- 80	- 70
Down	- 470	- 480

Deformation of the Central Cross Girders.

Deflections of the main cross girders of the drums were measured.
the big drum two instruments were placed under the intersection of
upper drum. girders and the main cross girders (south side)

The deflections under static load = 0.82 & 0.80 mms.
The corresponding calculated values are 0.82 & 0.86 "
The values measured at maximum speed 1.1 & 1.2 "
attained during test are
All deflections are downwards i.e. no hammering.

Rotation of the support on drum.

Angle of rotation measured at the bottom chord at the central
port of the big drum amounted to
The corresponding calculated value is 108"

TIME OF OPERATION.

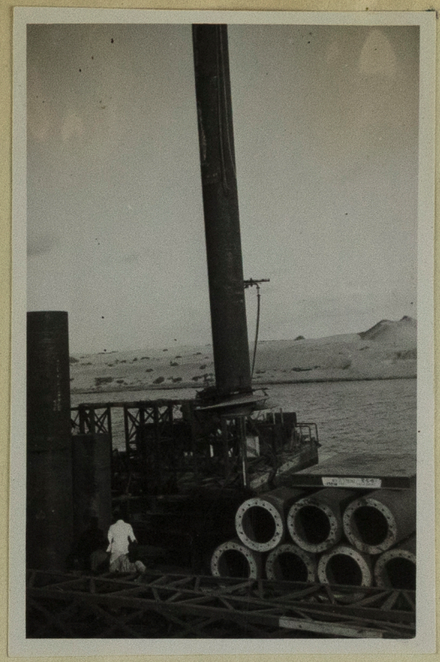
The measured time of operation is tabulated hereunder :-

Operation	Africa side	Asia Side	Remarks
	M. SEC.	M. SEC.	
Closing bridge	8 18	3 18	6 men at one arm only
Opening bridge	8 00	3 00	4 men
Wedging	4 30	3 30	3 "
Unwedging	3 30	3 30	3 "

The calculated time for opening or closing the bridge by 3 men
each arm of the key is:

Africa side 6 minutes
Asia Side 4 "

Sgd/ [illegible]



Screwing
Africa
Cylinders
25.12.41.



Screwing Africa cylinders - 3.1.42



Laying Shuttering Floor,
Africa Pivot Pier - 25.2.42.



Laying Shuttering Floor, Africa Pivot Pier, and screwing North Dolphin cylinders - 27.2.42.



Screwing Asia cylinders - 25.3.42.



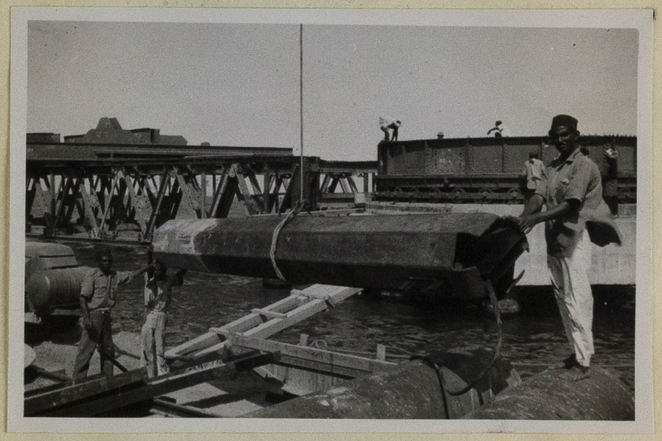
Erecting Africa turntable - 15.4.42.



Assembling cylinders on Africa Bund

for screwing on Asia side

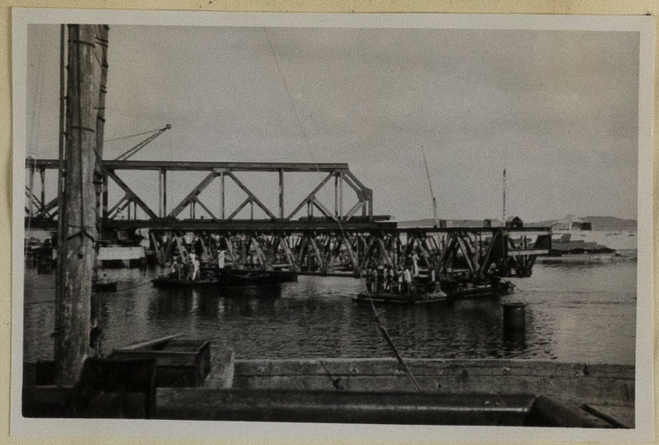
28.4.42.



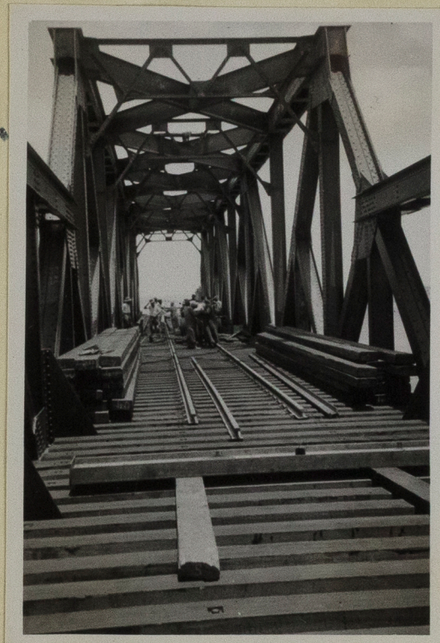
Removing Pilot tube to Asia Side - 28.4.42.



Erecting superstructure Africa span - 14.5.42.



Removing Hamilton Span (Falsework Africa Span) - 18.6.42.



Laying Deck and Rails Africa Span 24.6.42.



Adjusting Locking Gear, Africa Span 26.6.42



General View of Africa Span - 21.6.42.



Erecting Diagonals Asia Span - 2.7.42.



General view of Bridge from Asia bank - 4.8.42.



General view of Bridge from Asia bank - 4.8.42.



General view of Bridge from Africa bank - 25.8.42.



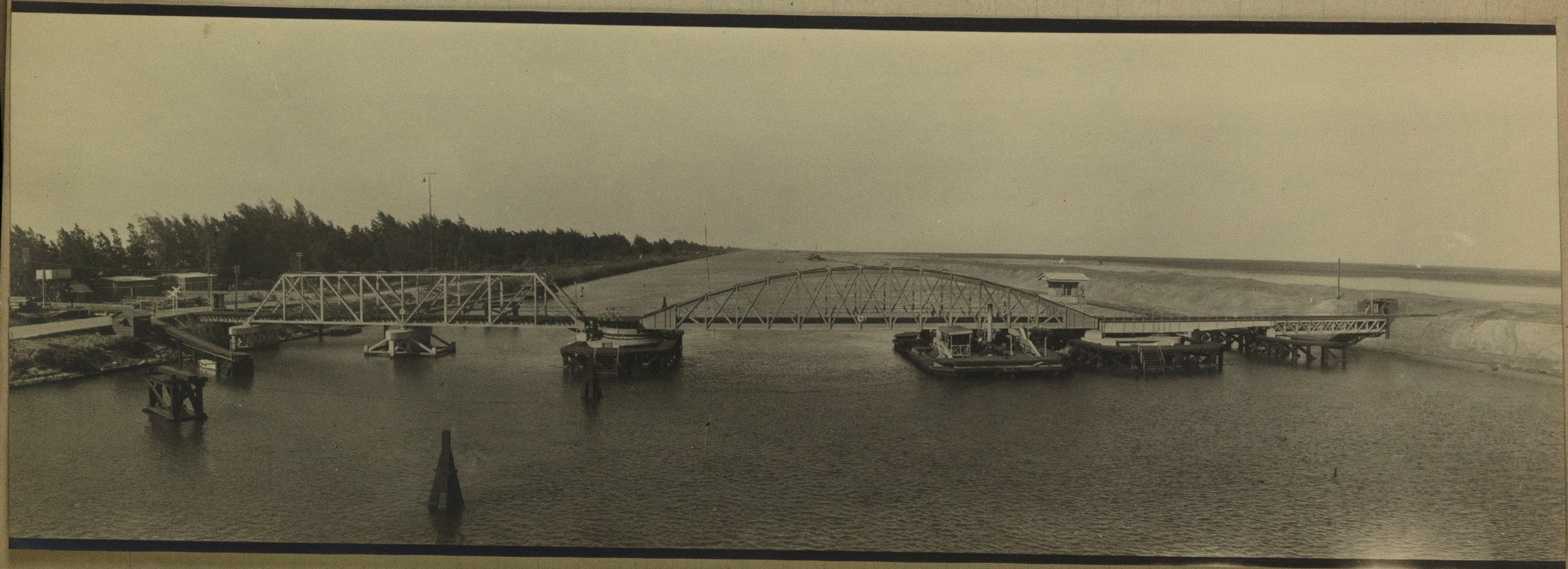












WORLD WAR I — 1917

[illegible] AT EL KANTARA



H-B-T 1941-42

42

D

15 1942

CAIRO TO BEIRUT BY TRAIN

SWING BRIDGE OVER SUEZ CANAL

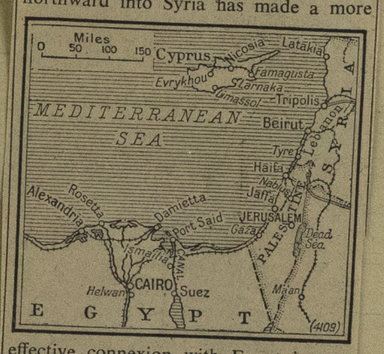
LINKING THE ARMIES

FROM OUR OWN CORRESPONDENT

CAIRO, AUG. 14

For the first time in history passenger trains are running across the Suez Canal from Egypt to Palestine. The Suez Canal Company has always been reluctant to have the canal bridged. During the last war a makeshift was contrived when the Palestine railway was originally built by means of a floating bridge, but this was abolished after the war, since when the only link between the Egyptian and Palestine railways has been a small, cumbersome train ferry, capable of handling only some 50 trucks a day.

The extension of the Palestine railway northward into Syria has made a more

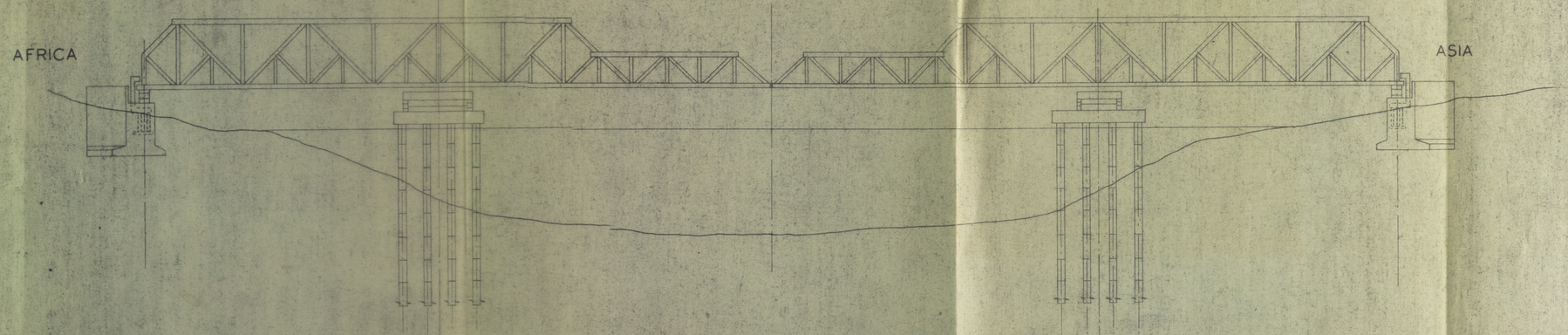


effective connexion with Egypt imperative. During the last year a new swing bridge has been built across the canal. This connects with the new railway line which runs on the east side of the canal from Kantara down to Suez roads.

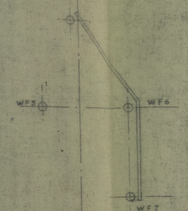
This is one of the most important items in the extensive railway development which has taken place in the Middle East to serve the needs of the Army. The position now is that trains can run direct from Cairo to Beirut.

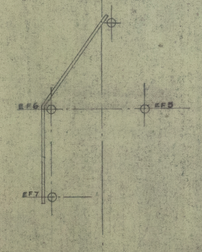
SUEZ CANAL BRIDGE PROGRESS DRAWING

SCALE:- 25 FEET TO 1 INCH



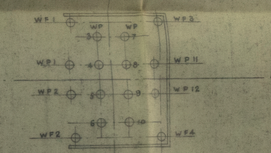
PILE	PITCHED	FINISHED
W.F. 5	Feb. 18th.	Feb. 20th.
W.F. 6	Feb. 22nd.	Feb. 24th.
W.F. 7	Feb. 25th.	Feb. 27th.

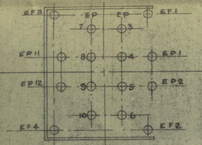




PILE	PITCHED	FINISHED
E.F. 7	May 11th.	May 12th.
E.F. 6	May 13th.	May 14th.
E.F. 5	May 15th.	May 16th.

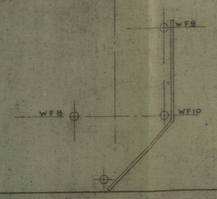
PILE	PITCHED	FINISHED
W.F. 2	Dec. 16th.	Dec. 23rd.
W.P. 1	Dec. 24th.	Jan. 1st.
W.F. 4	Dec. 24th.	Jan. 1st.
W.F. 1	Jan. 3rd.	Jan. 5th.
W.P. 3	Jan. 6th.	Jan. 15th.
W.P. 4	Jan. 9th.	Jan. 16th.
W.P. 6	Jan. 17th.	Jan. 23rd.
W.P. 5	Jan. 21st.	Jan. 24th.
W.P. 10	Jan. 28th.	Feb. 1st.
W.P. 9	Jan. 29th.	Feb. 1st.
W.P. 8	Feb. 2nd.	Feb. 6th.
W.P. 7	Feb. 4th.	Feb. 6th.
W.P. 12	Feb. 7th.	Feb. 10th.
W.P. 11	Feb. 8th.	Feb. 11th.
W.F. 3	Feb. 12th.	Feb. 13th.
W.F. 4	Feb. 14th.	Feb. 16th.

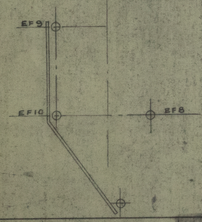




PILE	PITCHED	FINISHED
E.P. 6	March 14th.	March 31st.
E.P. 5	March 17th.	April 2nd.
E.P. 3	March 24th.	March 30th.
E.P. 4	March 26th.	March 30th.
E.P. 7	April 3rd.	April 5th.
E.P. 8	April 6th.	April 8th.
E.P. 9	April 9th.	April 11th.
E.P. 10	April 11th.	April 13th.
E.P. 12	April 14th.	April 16th.
E.P. 11	April 17th.	April 18th.
E.F. 4	April 19th.	April 21st.
E.F. 3	April 22nd.	April 23rd.
E.F. 2	April 25th.	April 27th.
E.P. 2	April 28th.	May 1st.
E.P. 1	May 2nd.	May 4th.
E.F. 1	May 5th.	May 7th.

PILE	PITCHED	FINISHED
W.F. 10	March 3rd.	March 5th.
W.F. 9	March 6th.	March 7th.
W.F. 8	March 9th.	March 10th.





PILE	PITCHED	FINISHED
E.F. 9	May 20th.	May 22nd.
E.F. 10	May 22nd.	May 23rd.
E.F. 8	May 26th.	May 28th.

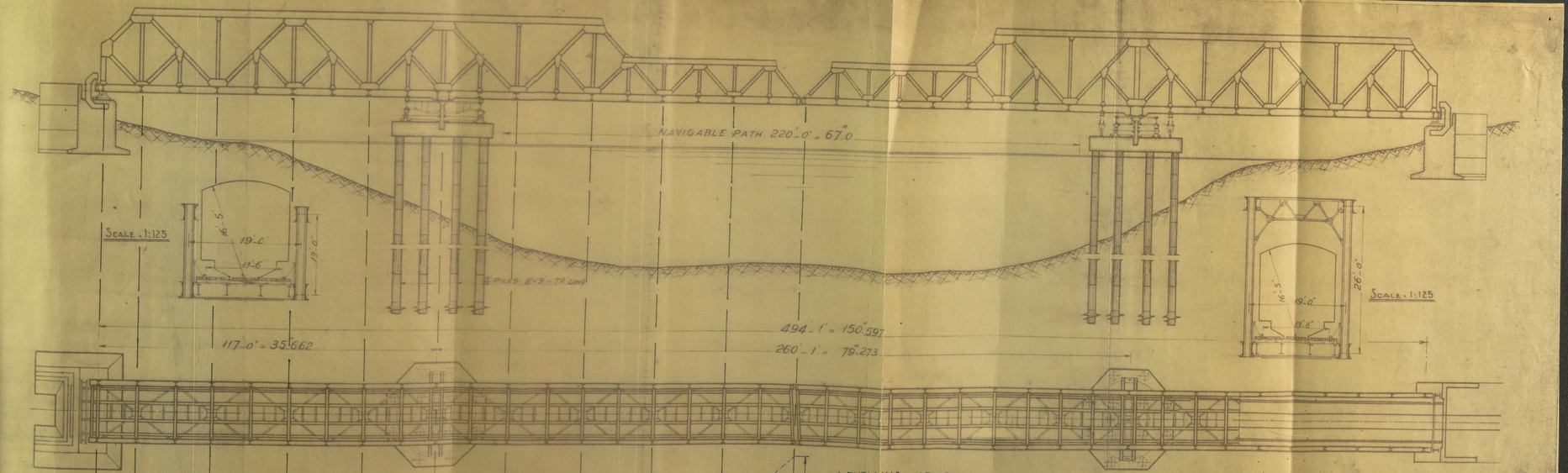
Screwing 16 pivot & fender piles .... 62 days (3·88 days/pile)
Screwing 6 dolphin piles ..... 22 days (3·67 days/pile)
Total time for screwing 22 piles .... 83 days (3·78 days/pile)

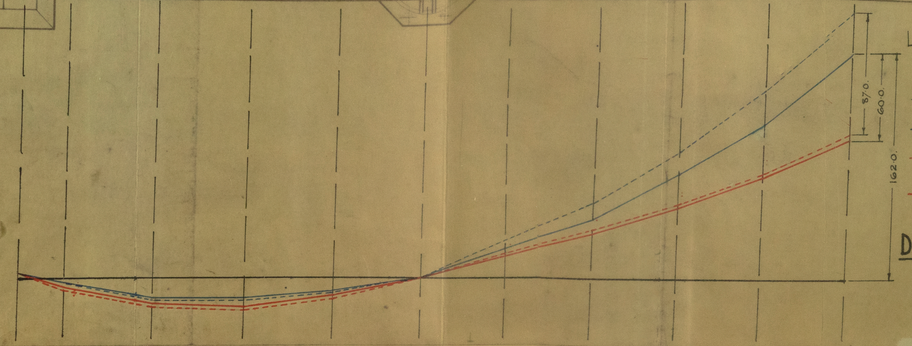
TOTAL TIME FOR SCREWING 44 PILES
164 DAYS (3·7 DAYS/PILE)

Screwing 16 pivot & fender piles .... 55 days (3·42 days/pile)
Screwing 6 dolphin piles ..... 18 days (3·00 days/pile)
Total time for screwing 22 piles .. 76 days (3·45 days/pile)

APPENDIX 2.

DRG. NO. 203/53.
TW/8492





LEVELLING OF BOTTOM CHORD.

VERTICAL SCALE :- 1:2.

- - - - CALCULATED LEVELS UNDER D.L. (STEEL & TIMBER).
—— ACTUAL LEVELS UNDER D.L.
- - - - CALCULATED LEVELS UNDER D.L. & TWO LOCOMOTIVES.
—— MEASURED LEVELS UNDER D.L. & TWO LOCOMOTIVES.

DEFLECTION DIAGRAM.

سكك حديد الحكومة المصرية
كوبري قنال السويس عند الفردان

BRIDGE OVER SUEZ CANAL AT EL-FERDAN.

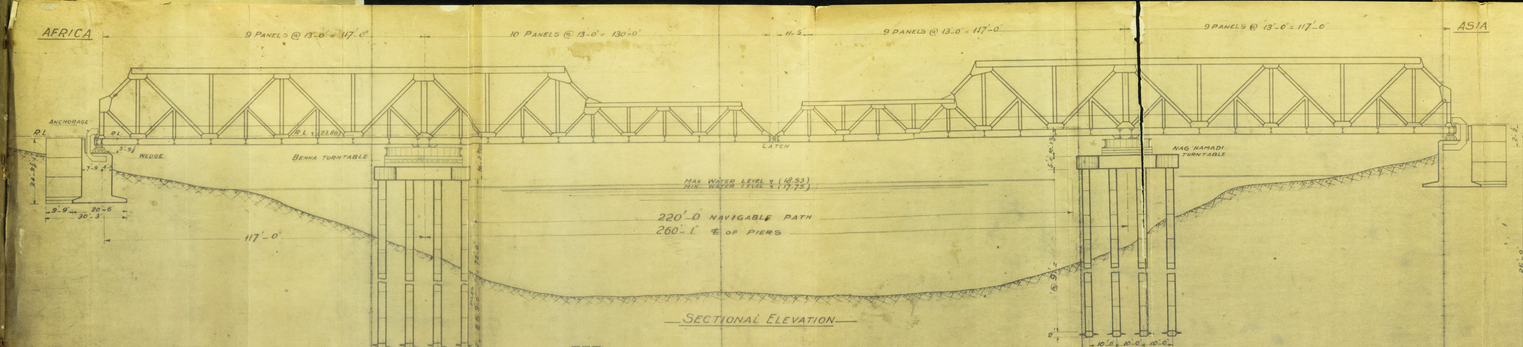
Scale = 1:250

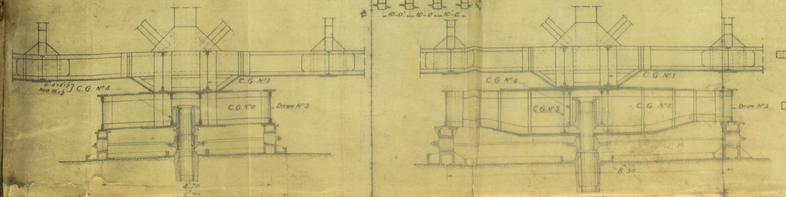
Mortada
CHIEF OF TECHNICAL OFFICE.

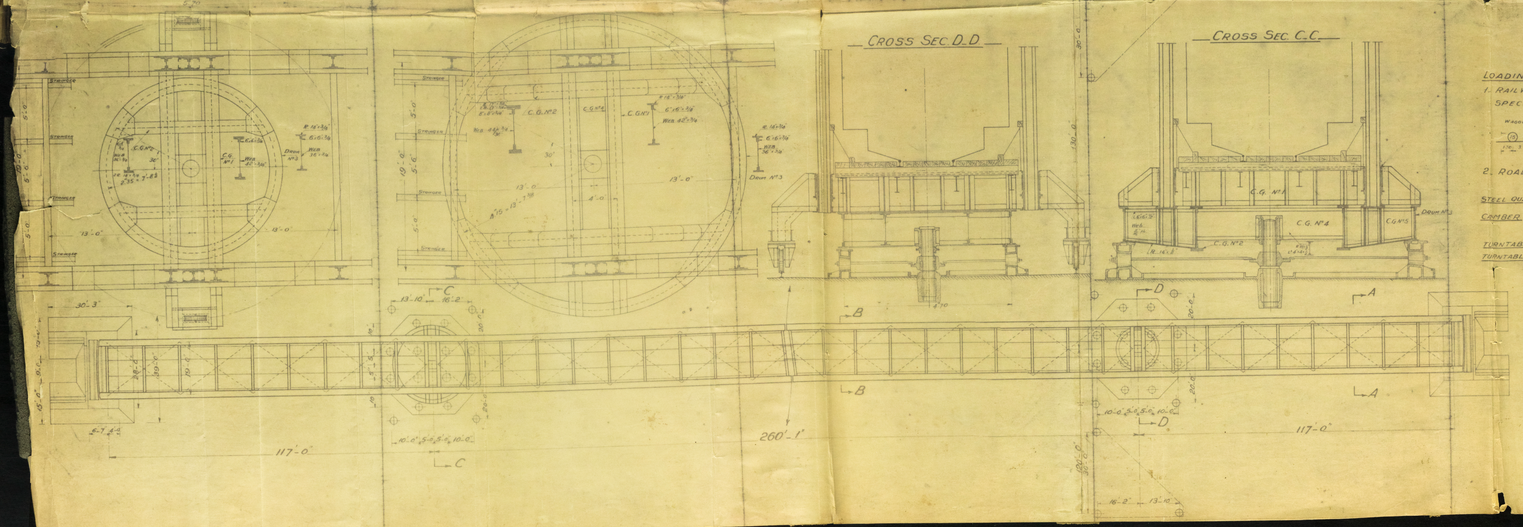
Asst. Chief Engineer.
1/Feb 1942 (BRIDGES)

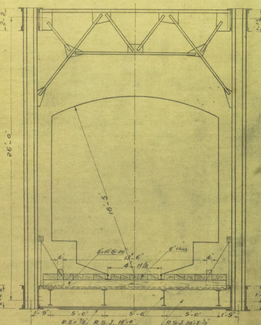
PS_a_68
16***

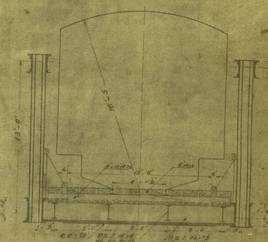
8,518/TN.











LOADING CAPACITY :-

1. RAILWAY TRACK ENGINE TYPE 118 + HALF THE IMPACT SPECIFIED BY THE E.S.R.

WAGON 30 TENDER 60 LOCOMOTIVE 76 TENDER 60 LOCOMOTIVE 76

2. ROAD TRACKS

FOR 20 VEHICLES :-

STEEL QUALITY ALLOWABLE SAFE WORKING STRESS OF 9000 lbs/in²

CAMBER BRIDGE DEAD & LIVE LOAD WITHOUT IMPACT 3" MINIMUM

(THIS CORRESPONDS TO AN ERECTION CAMBER OF 10")

TURNTABLE N°1 ENGLARGE AT BENHA

TURNTABLE N°2 & WEDGES RESULTING FROM NAG HAMADI

E.S.R. WAY & WORKS DEPT. - BRIDGE ENG^NG SECT.

SWING BRIDGE OVER SUEZ CANAL

(AT FERDAN ST.)

GENERAL PLAN.

SCALE : 1/16 = 1'
1/4 = 1

25 a 68
16 "

CHIEF OF TECHNICAL OFFICE

ASSISTANT CHIEF ENGINEER BRIDGES

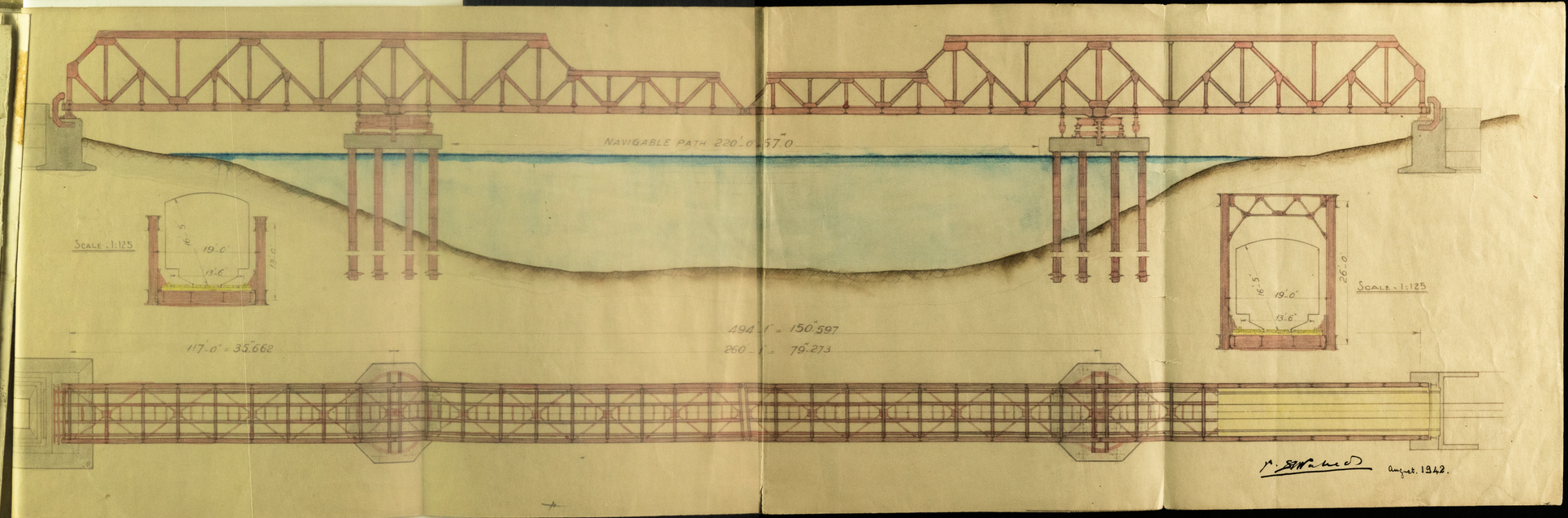
CANCELS & REPLACES DRAWING N° PS.D.02 10

APPROVED

CHIEF ENGINEER WAY & WORKS

DATE	RECEIVED	CHECKED	TRACED
2 JAN	G.W.	[illegible]	

8413/TH
JOB. 203.
FILE 1029


NAVIGABLE PATH 220'-0"-57'-0
SCALE :-1:125
16'-5"
19'-0"
13'-6"
13'-0"
117'-0" = 35'662
494'-1" = 150'597
260'-1" = 79'273
26'-0"
SCALE :-1:125
August. 1942.