THE SUKKUR BRIDGE.

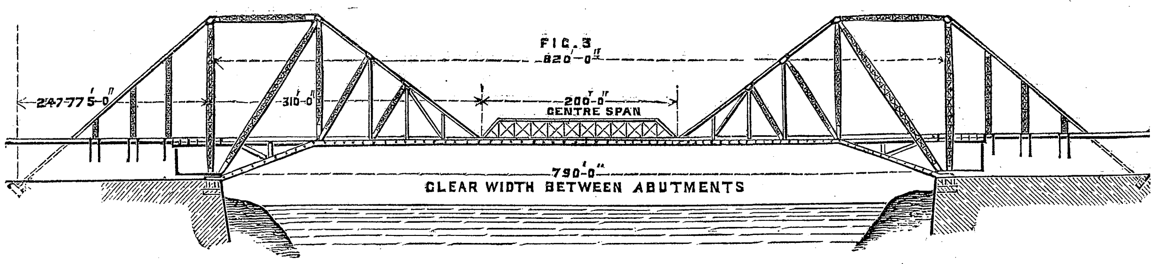
TRAVELLERS entering or leaving the port of London during the last few months have gazed with some perplexity on a huge edifice of timber which towers about 200ft. into the air on the river bank, nearly opposite Greenwich Hospital. The curious foreigner approaching the metropolis by water might imagine that some national monument was in course of erection, and that the choice of site on the low-lying Isle of Dogs was with a view of emulating Sir Christopher Wren's noble building opposite. We fear that if that prince of architects, whose engineering skill was the true basis of his art, could return to the city he did so much to embellish he would exclaim with horror at the form and proportions of the structure about which we write—namely, the Sukkur Bridge over the Indus, now in course of manufacture in the yard of Messrs. Westwood and Bailie, who are erecting it temporarily on the lofty wooden staging above referred to.

During the last ten years the Government of India has been extending the State lines of railway to the north-west, deeming it a wise expenditure of money for military defence to connect the frontier with the whole railway system of British India. During each year of this period many thousands of tons of iron bridges, and lately of steel bridges, have been sent from this country, some of the more important, such as those over the Chenab and Nerbudda rivers, having been described in THE ENGINEER at the time of their construction. One of the natural obstacles on the British side of the mountain frontier is the Indus river, which, from the time of Alexander the Great, has hindered, more or less successfully, the advance of the invader from the north. At Attock, the point where Alexander crossed the Indus, on the direct road from Cabul, through Peshawur, the Indian Government has already built a bridge, the piers and superstructure of which formed a subject of considerable interest at the time, and it is now intended to bridge the river many miles lower down, at Sukkur. At this point the stream is about 800ft. wide, and at certain seasons the volume of water, always considerable, is greatly increased, so that serious difficulties would arise in building piers in mid-channel. Not only, therefore, was a bridge of a single span appropriate, but one easy of erection. The arch, the cantilever, the girder, and the suspension form of bridge were all available, but the skill or genius of the designer was necessary to select, elaborate, or combine the principle best suited to the site and purpose. Such skill is not wanting in the world; bridges like that lately constructed over the Douro, illustrated in THE ENGINEER and obtained by open competition, and numerous other structures designed in England and America during the last twenty years, all prove that original ideas and fertility of resource are forthcoming when sought after. The problem for the Sukkur Bridge was an interesting one to an engineer; it is now in course of solution, and, we are sorry to say, in a very unsatisfactory way, in our opinion.

Two years ago, in THE ENGINEER of 11th July, 1884, we took occasion in an article on "Suspension and Cantilever Bridges," to criticise the design of the Sukkur Bridge as then put forward by Mr. Rendel, the Consulting Engineer for Railways of the Indian Government, and to point out that the design was not only bad but gratuitously ugly. We reproduce above the elevation of the bridge, from which our readers can draw their own conclusions; and now that the erection of the structure in India is about to commence, we have again to protest against a system of management which allows so inferior a specimen of construction to be sent from this country to our greatest dependency. From each shore a cantilever is built forward 310ft., and over the middle gap, and resting on the outer ends of the cantilevers, a girder bridge of 200ft. is constructed, thus making up a total span of 820ft. The contract for the cantilevers was given out two years ago; the tenders for the girder span were sent in last week, and the contract for it will probably be arranged immediately. As we said in our article on the subject two years ago, "A derrick, the half of an English roof truss, a whipple girder, the other half of the roof truss and another derrick, are very excellent things in themselves; but to string them together upon one line and thereby make a bridge, is not engineering—nor is it architecture."

A consulting engineer to a railway company, and much more one to a Government having a variety of public works on hand, has important functions to perform, and in the routine of his duties has not only to choose, inspect, and control, but to design what may be needed for ordinary purposes. But we protest against a system that too often prevails in this country, and in no other, of allowing the consulting engineer who happens to be in office at a particular time to retain in his own hands the designing of engineering works of exceptional magnitude and importance. Even if the Council of India did not see this in the present case, their engineer should have done so for them, for there is no greater sign of wisdom than to know the limit of one's own knowledge; and we unhesitatingly assert that an engineer of Mr. Rendel's experience and standing should have been strong and candid enough to tell the Government of India that he could serve them best by advising them in a wider choice than his own office afforded. He elected not to do so, and the result will be apparent when the Sukkur Bridge is erected.

On this occasion the poverty of design is followed by an equal want of judgment or courage in carrying it out. The preliminary erection of the bridge in England is as unnecessary as it is costly, and seems to indicate a want of confidence either in the design or in the correct setting out of the various parts. The shape of pieces, the intricacy of their intersections, and the difficulties of erection are much more complicated in the Forth Bridge than in the Sukkur Bridge; but what would be thought of Sir John Fowler if he proposed to erect the former in Dalmeny Park before building it over the deep water? There are bridge builders in England as elsewhere who would undertake the responsibility of fixing the Sukkur Bridge in place as well as making it without any preliminary erection in the factory. We do not know what price the English manufacturers are being paid for the foundations and timber staging as well as for the labour in putting up and taking down the metallic structure, but we have little doubt that the bridge, when finally erected, will have cost at least £50,000 more than it might otherwise have done. We wish, at any rate, to put on record the fact that the design, though the work of a Government official engineer, is not approved by those in this country best able to judge, and in no way represents the present engineering talent of Great Britain.



THE SUKKUR BRIDGE.

LITERATURE.

The Rudiments of Mineralogy. By ALEXANDER RAMSAY. Third Edition, 12mo., 359 pp. London: Crosby Lockwood and Co. 1885.

THIS volume—founded upon the small treatise by the late Miss Varley, that appeared among the earliest of Weale's series—has by successive accretions grown to more than twice the original size in the present issue. Some of the additional matter is excellent and well chosen, but the same qualification cannot be extended to the whole of it, as a considerable amount of space that might have been usefully devoted to the extension of the text on its original plan has been given up to matters that are not very intimately connected with the immediate subject of the book. For example, systematic crystallography is treated in about six pages, which contains the barest outline of the "early French" system of classification of Haüy and De Lisle by primitive forms, which though no doubt of historical interest, is of little value for rudimentary teaching at the present time, as the use of this method is practically confined to the country of its origin; and even there the use of Miller's notation at any rate conjointly with the official system, if not exclusively, is becoming general with mineralogical writers. It is certainly remarkable that no mention has been made of the crystalographic methods of Weiss and Miller, which are now in probably nine-tenths of the mineralogical literature of the present day; and the omission can scarcely be charged to want of room, as more than twenty pages of the introductory part are filled with discussions of subjects such as the properties of gases, formulæ for steam, specific heat, composition of marsh gas, and similar matters which, though no doubt interesting and useful in the study of general chemistry, have not very much to do with mineralogy proper. In fact this part of the book looks as though some pages of an elementary treatise on chemistry had wandered into the printing office and got mixed up with the text by mistake. The author has been at the trouble of recomputing the specific grades of minerals on the hydrogen scale; that is, the figures in ordinary use are multiplied by the number 11,178, representing the density of water when hydrogen is unity, and the results are given throughout the text in addition to the ordinary figures. The purpose of this addition is not at all clear; it can scarcely be to assist the memory. Probably most persons would more readily realise the density of platinum as 21·5 times that of water than as 239,327 times that of hydrogen. The latter may be more scientific, but it is decidedly more clumsy than the former While on this subject it may be pointed out that the author's figures do not tally with his statement as to the relative densities of the metals of the platinum group, for at page 100 it is stated that platinum is the heaviest substance known except osmium and iridium; while in the table of the elements, at page 25, one of these metals is said to be of the same density as platinum and the other sowewhat lighter, or in hydrogenous terms the figures given are too low by ten or twelve thousand units. The descriptive part contains notices of a large number of species, far larger indeed than there is required in a first rudimentary book; but few of them can be said to be well described. This is in great part to be attributed to the neglect of methodic nomenclature, crystals being described by vague references to shapes rather than by the terms of systematic crystallography. Thus, witherite is said to occur in hexagonal prisms and double hexagonal pyramids, although immediately before the angle of the prism is given at 118 deg. 30 sec. What is really meant is that the crystals are contractions producing six-sided prisms which resemble those of the hexagonal system, but have no structural relation to them. All the minerals of the tenstone-zircon group, although correctly figured as tetragonal, are incorrectly attributed to the rhombic system, and include prisms of twelve sides, or four that are usually supposed to be incompatible with the symmetry of the system. The description of the commoner minerals contains much information that is more curious than accurate. Thus, among other things we are told that the European silver ores are generally richer than those of South America; that all the schistic rocks contain gold; that coal beds are immense masses of moist vegetation, undergoing decomposition; that iron pyrites occur almost everywhere but never in large masses, and is seldom mined except for the sulphur and gold contained. From the latter statement we may conclude that the author has never heard of Rio Tinto, Tharsis, and the allied coppery pyrite masses in south-western Spain and Portugal. The principal lead mines in France are said to be at Poullaouen, and Huelgoal, in Brittany, which mines have, however, been abandoned for a long time, while, on the other hand, very productive mines have been worked with English management at Pontgebaud, in Auvergne, for more than a quarter of a century. Surely some notice of the latter locality might have been given. Galena is also said to have some of the lead replaced by an equivalent proportion of silver, copper, antimony, bismuth, iron, and platinum. It would be interesting to know what evidence there is for this remarkable statement. Probably many of the above blemishes upon an otherwise useful little book are to be attributed to an exaggerated respect for stereotype plates, but it is to be hoped that the work will be more thoroughly reviewed, especially as regards the localities, when it is next issued.

Geology: Chemical, Physical, and Stratigraphical. Vol. I. By JOSEPH PRESTWICH, F.R.S. Royal 8vo. pp. 472. Oxford Clarendon Press. 1886.

THIS is the first half of a systematic treatise on geology by the veteran professor who so worthily maintains the reputation of the Oxford School of Geologists, established by his predecessors, Buckland, Strickland, and more particularly the late Professor John Phillips. Professor Prestwich's long and distinguished career as an observer of stratigraphical phenomena, and in the comparison and classification of the newer sedimentary formations of this country with those of the continent of Europe, has brought him into very close contact with the geologists of neighbouring countries, and more particularly those of Belgium and France, which has developed a catholicity of thought not very common among his English contemporaries, with whom the Lyellian hypothesis of uniformity in geological action has until comparatively lately been generally accepted as sufficient. The author has, however, long been of opinion that the phenomena of geology, so far from showing uniformity of action in all time, present an unceasing series of changes dependent upon the circumstances of the period, and that while the laws governing such changes are unchangeable and permanent as the material universe itself, their action, as new conditions and combinations arose in the course of geological history, has been subject to constant variation both in degree and intensity.

The work is divided into four parts, the first covering what are usually known as mineralogy and petrography, while the second deals with the mode of action of geological agencies under existing and past conditions, these together make up the present volume. The third and fourth parts, treating of the succession of the sedimentary strata and of the contained fossils and of some theoretical considerations as to physical conditions prevailing during former periods of the earth's history, will form the second volume, which, we understand, is now nearly completed. From the circumstance that the work is still unfinished, it is difficult to form any very exact appreciation of the author's conclusions, as the volume before us deals mainly with matters of definition and detail; but the manner in which these different subjects are treated shows considerable differences from that ordinarily adopted. Then the question of the alteration of rocks by atmospheric agency is very fully dealt with on the ground that its importance on questions of denudation and time has not hitherto received sufficient consideration. It is clear that all sedimentary stratas have been derived from pre-existing rocks, and that the estimates of time required for their accumulation have been based upon figures derived from observations of denudation as now going on. Such observations, however, deal mainly with sedimentary strata which are comparatively unchangeable except by bodily transportation; while, on the other hand, crystalline rocks, such as must have formed the entire surface of the earth before the deposition of the earliest stratified rocks, are much more rapidly altered by the removal of their alkaline silicates and the formation of China clay, so that it is probable that degradation and denudation may in earlier times have been much more rapid than at present, and that in consequence of greater abundance of available material, the earlier formations were built up of larger extent and thickness than those that have followed. On this ground the author considers all calculations of the length of geological time to be fallacious, and to have led to serious error, the unlimited length commonly assumed being due to the use of data representing a special and late order of things, and which are not applicable to earlier geological periods. These conclusions may, and no doubt will, be questioned by many observers, but there can be no doubt of the cogency and originality of the author's reasoning. The chapter on the circulation of water in rocks is, as might be expected from such a perfect master of the subject, exceedingly good. The whole of the circumstances connected with the absorption and retention of rainfall by porous strata, and the circulation, underground circulation, and delivery in springs, being fully treated, with excellent illustrative sections of the London basin and of the line of chalk hills on the north of London, showing the levels of constant and temporary saturation. The subjects of faulting, folding, and mountain elevation are also admirably treated, the latest researches, including those of Stapff in the St. Gothard tunnel, being used in illustration. Mineral veins receive much fuller consideration than is usual in geological treatises; but here the author has not been quite

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The principal things seen here are torpedo boats in course of construction for the British and Foreign governments. In this establishment the entire process is seen of making the machinery and also building the vessels.

SUKKUR BRIDGE CANTILEVERS.

The Sukkur Bridge, the cantilevers of which are being built by Messrs. Westwood, Baillie and Co., London Yard Iron Works, Poplar, is intended to span the Indus at the town of Sukkur, where the river is divided into two streams flowing through the Sukkur Pass and the Rohri Pass. Sukkur is about 300 miles from the mouth of the Indus; and there is at present a steam ferry connecting the railway from Karachi and the railway to Quetta on the west side of the river with the lines to Lahore and Delhi on the east side. The only bridge over the Indus at present is at Attock, which is 500 miles north of Sukkur, and near Peshawur in the extreme north-west of India. The Sukkur bridge will therefore form a most important link in the chain of frontier lines now being built, and will afford the same direct communication to the Bolan Pass and Candahar that the Attock bridge does to Peshawur and Cabul. The Sukkur Pass has already been bridged by three spans of 278 feet, 230 feet, and 93 feet; and the Rohri Pass is to be crossed by the Sukkur bridge now constructing in one span of 790 feet in the clear, or 820 feet between centres of main pillars. The river in this pass is of great depth and swiftness, the current in floods having a velocity of ten miles per hour. The bed of the river and its banks are of limestone rock. Above and below Sukkur the river is wide and sluggish, flowing like most Indian rivers through an alluvial plain. Owing to the great depth to which the piers would have had to be sunk, and the great length of the bridge, it was thought that a bridge over any wider part of the river would have been more costly than the Sukkur bridge, even with its inevitably large span. The type of bridge to be adopted was the subject of long and careful consideration by the government authorities both in India and in England, the result being the adoption of the cantilever system. The cantilevers are each 310 feet in length, and the centre span resting on them is to be a lattice girder of 200 feet. As there is but one span, anchorage has to be provided on each side. The following are the main dimensions of the bridge:—extreme height of cantilever from under bedplate, 173 feet; height of rail from under bedplate, 40 feet; length of back guys, 280 feet and 300 feet; width of bridge between centres of main members of bedplate, 100 feet; width of bridge between centres of main members at end of cantilever, 20 feet; width between centres of back guys, 20 feet. The bridge is for a single line of railway of 5 feet 6 inches gauge. It is to be constructed entirely of mild steel plates and bars, supplied by Messrs. Beardmore, Parkhead, Glasgow, ranging from $1\frac{1}{4}$ inch to $\frac{5}{16}$ inch in thickness, and riveted together with steel rivets. The long struts are rectangular in section; each corner of the rectangle consists of a curved plate with angle-bars on its edges, and the faces of the rectangle are occupied by transverse and diagonal bracing. Longitudinally the struts are curved on all four faces, tapering from the middle towards the ends. The roadway girders are of steel, 4 feet 6 inches in depth and at a uniform distance of 18 feet apart; the cross girders are spaced 8 feet apart. The floor of the bridge is of corrugated steel plating. The back guys are more heavily strained than any other members; the stress provided for in each of the two guys of the cantilever amounts to 1,200 tons, and arises firstly from a load of 300 tons imposed by the centre span upon the nose of the cantilever, secondly from the dead weight of the cantilever itself, thirdly from a rolling load covering the cantilever, and fourthly from wind. The anchors are buried in a large mass of concrete, and are built up of steel plates and angle-bars. Each anchor measures 32 feet by 12 feet in a plane at right angles to the line of stress. The total weight of steel in the two cantilevers, including the back guys and anchors but excluding the central span, is nearly 3,000 tons. Owing to the fact that no staging can be employed in the erection of the bridge in India, and to the difficulty of carrying out work at the site, it was thought advisable to adopt with these cantilevers the same plan that is pursued with all other bridges for India, namely, to erect them in England complete, in order to ensure a perfect fit and accuracy of workmanship in all parts. A great saving of time and expense is thereby effected in the erection of the work abroad, and a much better result is obtained than could be got in any other way. On this plan the last span of the Sutlej bridge, weighing 420 tons, was erected in forty-five working hours. The bridge has been designed by Mr. A. M. Rendel, the consulting engineer to the Indian government.

Among other large bridges built at these works for the Indian government are the Chenab bridge of sixty-four spans, the Empress bridge of sixteen spans over the Sutlej, and the Attock bridge of five spans over the Indus.
