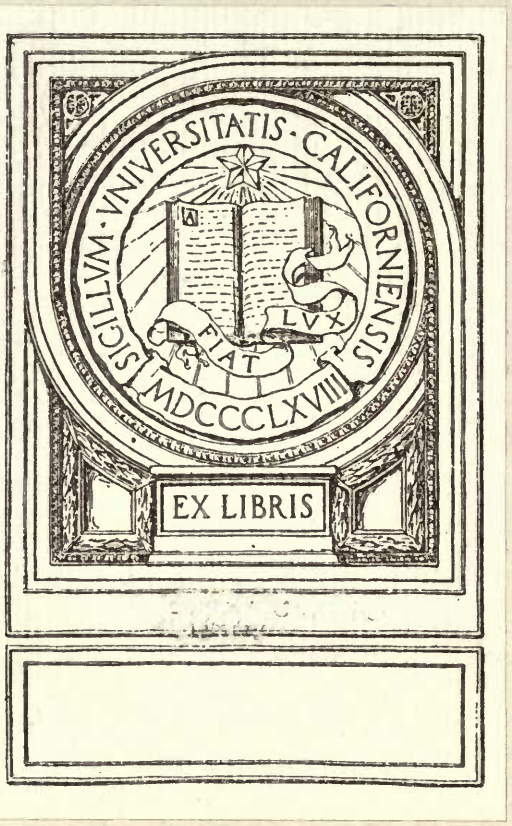
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REPORT

by

Prof. Comm. G. Fantoli

on

ROCK FILL DAMS

1918

Translated by

M. M. O'Shaughnessy

City Engineer of San Francisco

1920

MINISTRY OF PUBLIC WORKS

Supreme Council of Public Water-Works

Prof. Comm. G. FANTOLI

REPORT

to the

SUPREME COUNCIL OF WATER-WORKS

concerning

THE ARGUMENT ABOUT ROCK-FILL DAMS

and

THE PROBLEM OF THE RESERVOIRS IN ITALY

ROME

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1918

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I. Chief characteristics of the propaganda in favor of the Rock Dams - incentive for the present writings.

The vote, Dec. 6, 1916, of the Supreme Council of the L. L. P. W. gave its assent to the official construction of Rock Dams, even of great height. It is a remarkable fact the Honorable Prof. Luigi Luiggi, an authoritative member of the said Council, also of our Council of Public Works, and Chief-Inspector of Civil Engineering, took most active promoter of this Rock Fill Dam construction.

This vote, if I do not wrongly accuse them, adopted inconsciously [illegible] the unsafe proposition, thus giving free scope to the projects that encouraged the irresponsible attitudes which become, in a matter-of-fact, a consideration of the technical value of the first quality. Under given conditions it might be permissible to build Rock Dams, in some places, 40 meters high, even in others, those of 15 meters should not be undertaken.

But the propaganda of the brilliant chemist, (Luiggi) in search of [illegible] the sources of information, [illegible] to me, were entirely [illegible] being based on inspection not altogether impartial and positive. [illegible] characteristics constitute a danger for research and also for progress of the said propaganda. As proof, I will give quotations and I shall refer

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Necessity of the present decided reaction for the safety of our valleys, and also in the future interest of Reservoirs in Italy.

1. Chief characteristics of the propaganda in favor of the Rock Dams - Incentive for the present writings.

The vote, Dec. 30, 1916, of the Supreme Council of the L. L. P. P. gave its sanction to the official construction of Rock Dams, even of great height. It is a remarkable fact the Honorable Prof. Luigi Luiggi, an authoritative member of the said Council, also of our Council of Water-Works, and chief-Inspector of Civil Engineering, is a most active promoter of this Rock Fill Dam construction.

This vote, if I do not wrongly accuse them, admitted intentionally just the simple proposition, thus giving free scope to the projects that overcome the conventional altitudes which become, as a matter-of-fact, a consideration of the technical value of the flow capacity. Under given conditions it might be permissible to build Rock Dams, in some places, 30 meters high, while in others, those of 15 meters should not be undertaken.

But the propaganda of the brilliant apostle, (Luiggi) is based on only a few sources of information, which, according to me, are entirely useless, being based on inspection not altogether impartial and positive. These characteristics constitute at once the strength and also the weakness of the said propaganda. As proof, I will give quotations and I shall need

to cite many in these pages. Here it is sufficient to announce that the absolute predominance of Rock Fill Dams is asserted, without the least suspicion of a doubt.

They place among the antiquities, in regard to their application in cases of notable height, the type of Dams with "gravity section" - "which are for this reason to have no imitators in the future", More recent conclusions are found in the following terms:-

"The Rock Fill Dams" represent the ideal for the high mountain regions and also for the sections subject to seismic shocks; that is they can efficaciously resist contigencies arising from overflow, infiltration, and underpressure, which are the destruction of earth or masonry dams. They can also resist the earthquakes as was proven by the good conservation of the California Dams of this type even after the violent earthquake which razed to the ground the City of San Francisco". (Giornale del Genio Civile. Civil Eng. Journal, Jan. 31, 1917, page 25)

Or again:-

"For the Valleys of the Alps or the high Apennines, for those of Calabria and Sicily subjected to seismic shocks, or for Lybia - where there is difficulty of transportation, and where hand-labor is also lacking, the Rock Fill Dams offer a more simple, rapid, economical, and above all, a more secure construction, even in the cases of earthquakes, and are for this reason worthy of the faith of our engineers. They are especially adaptable for high mountain lakes; and in fact, as already stated, the Council of Public Works in its meeting of December 30, 1916, has definitely admitted it." (Annali Societa Ingagneri Italiani, Mar. 1, 1918, page 72.)

Or again:-

"In seismic regions, equally, the Rock Dams are absolutely to be preferred to all others, as much for their easy construction as for their stability under all circumstances. And it is to this type of Dam that the

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"For the Valleys of the Alps or the high Apennines, for those of Calabria and Sicily subjected to seismic shocks, or for Lydia - where the difficulty of transportation, and where hand-labor is also lacking, the Rock Fill Dams offer a more simple, rapid, economical, and above all, a more secure construction, even in the cases of earthquakes, and are for t reason worthy of the faith of our engineers. They are especially adapted for high mountain Dams; and in fact, as already stated, the Council of Public Works in the meeting of December 20, 1915, was definitely inclined to it." (Annali Scuola Ingegneri Italiani, Dec. 1, 1916, page 72.)

Or again:-

"In seismic regions, equally, the Rock Dams are specially to be preferred to all others, as much for their easy construction as for their stability under all circumstances. And it is to this type of Dam that the

that the Italian Engineers will do well to aspire in projecting Dams in the high Apline valleys, and above all, in the Apennines so subjected to seismic movements, abandoning the old type with "gravity section" so much used in the past, when they were constructing at low elevations, but too inconvenient in the high mountains, rather costly, and that no one can have a reason for preferring to Rock Dams". (Annali Societa Ingegneri Italiani, Mar. 1, 1918, page 73.

In the chronicles of the technical papers, frequent notices, whose author is not mentioned, mention more ambitious projects in regard to Rock Dams. These finally reach our office, and, with clever, inciting arguments, fortify the statistical claims of the preceding projects and warmly praise this type of Dam.

The more recent reference, concerning the project of a Rock Dam about 75 meters high in the Apennine Valley of Enza, is considered specially for the constructions in Calabria and Sicily.

"On account of the seismic movement, the Rock Dams are the only ones advised, as experience proves in several instances in California, the classic land of Rock Dams and of strong seismic shocks". (Annali Societa Ingegneri Italiani, June 16, 1918, page 187.

It is conceivable that the recommendations, so constantly urged with examples of the absolute prevalence of the merits of the Rock type Dam, for its applicability in the Alps, the Apennines, and in all seismic countries, etc. wherever the mountain dams occur, must be decided by more than a suggestion submitted to cautious criticism; because the propaganda bears, so to speak, the personality of a brilliant scholar, a high functionary of Civil Engineering, a promoter of the aforesaid vote, a member of the Supreme Adjudication Board where things are judged and ordered.

The complex suggestion, which it is not necessary to analyze here

---

with psychological subtlety in its diverse factors, is also favored by other tangible arguments handled by the shrewd practice of the Projectors; the manner of procedure shortened and explained by most pleasing reasoning, the doing-away-with, or at least the greatly modifying of many old considerations concerning the quality of the natural foundations, the enormous economy that follows the adoption of a more easy construction. In fact, as will be seen, among the many merits given, there is the one, and it would be of real worth, that the Rock Dams --- "do not need to be placed on compact rock as is indispensable for masonry dams, a foundation of good clay or even of moraine being sufficient, because precautions are taken by which these foundations cannot be washed away or eroded in any way." (G.G.C. Jan. 31, 1917, page 25.)

On account of this, several Administrations, whether of the Old School or the New School, intested in the search for mountain locations, are agreed at least in this tendency, which has gone beyond the incipient stage, of following passively in the projects of reservoirs, the smooth, easy way of Rock Dam Construction, Easy way, I said, and so it is, in the public mind, even though the Supreme Water Council has not yet pronounced itself in regard to this matter, having held for many months and still holding in reserve its course of action concerning Rock Dams.

In fact, the admission in only one case (of the use of Rock Dams) should not be held as a technical victory in the entire Council, any more than the recent incidental passing of a vote (in regard to the same) which I learned of a short time ago, after a forced, protracted absence.

Therefore, the passage of the vote above referred to, according to which the manner of construction of the rock dams, "with a layer of cement and superior asphalt-bitumen on the side toward the water, corresponds to the rules of today for the construction at those altitudes (Alpine Valleys)", could be considered as a most important decision which, in my opinion, cannot be discussed except in a separate treatise".

with physiological subsidy in its diverse factors, is also favored by other tangible arguments handed by the skewed practice of the Projectors: the manner of procedure shortened and explained by more pleasing reasonings the doing-away-with, or at least the greatly modifying of many old considerations concerning the quality of the natural foundations, the enormous economy that follows the adoption of a more easy construction. In fact, as will be seen, among the many merits given, there is the one, and it would be of real worth, that the Hook Dams --- "do not need to be placed on compact rock as is indispensable for masonry dams, a foundation of good clay or even of moraine being sufficient, because precautions are taken by which those foundations cannot be washed away or eroded in any way."

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This refelction, and other serious motives that are developed from the examining of the recent members of the "Instruttorie", and above all the character and consistency of the propaganda in favor of Rock Dams, caused me to decide to take my stand against the current tendency of the day, and to express my deduction obtained through laborious meditation, and firmly opposed to the exaltation of Rock Dams.

2. Need of a more general, independent Study.

Objects of these investigations.

On the other hand, the Council will shortly, through sheer necessity become the center of a competent and special investigation concerning the most important question that comes within its scope, that of the High Dams for Reservoirs.

I say a "special examination" because it must be thoroughly permeated with the truth of the orohydrographic, the climatic, the demographic conditions which are entirely forgotten in the easy reference to divers geographic and demographic conditions.

One of the scopes of this work is to promote an important official research which is already being clamored for by certain authorities that are alarmed (1, page 30). Other reflections (studies) will show the values of this plan.

In the "Instruttorie" to which I alluded, and in some others (L.H.P. numbers) more recent, there is, on the one hand the opposition of the Surveyors of the Communes lying below the places for proposed high dams, learned Surveyors opposed to Rock Dams, more because of instinctive lack of faith than on account of reason and knowledge, which opposition is very real even if it is weak; on the other hand, there are opposed to these, the Projectors who, in the face of observation and defense, conclude always with the argument that all criticism should be abolished.

Omitting the greater number of amplifications, this reasoning is held

in the following terms:

"The most dependable proof, that Rock Dams are those that from now on present the best requisites, is given in the well-known deliberations of the Supreme Council of the L.L.P.P. that advises and approves them.

It is sufficient to refer to the writings of Prof. Luiggi, Chief Inspector of Civil Engineering, the warmest supporter of Rock Fill Dams, the one that has made himself their apostle after profound studies on the on the problem, (probably L.H.P.) be it with laborious research and with a visit made by him to America, Australia, Europe, etc.

There follow as axioms, the passages I have already cited, and similar ones.

Such an argument is regarded as a guarantee of victory.

Among the contenders are the officials, who have in hand the "Instruttori and are evidently placed in a most delicate position as regards the freedom of their judgment, for we must admit, the project of High Dams, an entirely new one, is very difficult and complex.

Thus, for example, in the most important and most discussed, recent "Instruttorie", they testify in accord with the Projectors, that the presence of ice in the frozen Alpine lakes will have no influence on the Dams, "because this will evidently not augment the hydrostatic pressure due to the shut-in water".

But, aside from this point of inherent "Ice-pressure", there are others of grave moment debated in their own late technical publications, and especially in American publications:- the phenomena of under-pressure, of the transfusion of water in time under slow pressure into the bodies of the Dams, the question of manimum deflux, etc. all of which need an adjournment for in reality, it is difficult to know definitely about a live subject in process of evolution and to treat it in a scholarly way. The foreign texts are the best compiled on the subject.

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But, aside from this point of inherent "ice-pressure", there are other of grave moment debated in their own late technical publications, and especially in American publications:- the phenomena of water-pressure, of the transmission of water in time under slow pressure into the bodies of the Dams, the question of maximum deflux, etc. all of which need an adjournment for in reality, it is difficult to know definitely about a live subject in process of evolution and to treat it in a scholarly way. The foreign texts are the best compiled on the subject.

This is stated as a synthetic impression which is the result of the examination of some cases given in the "Instruttorie", and which proves a present need for serious, general study, for general guidance and application. This study must be promoted by the Council with the collaboration of some technicians and specialists on the subject.

I will permit myself to expound, a little later, a proposition that is most urgent for safety, the revision of the flow capacity in executive projects for Rock Dams, it being imperative, as I will show that overflow in a rock-dam means most probably the destruction of the said dam. Thus the complete, arduous, uncertain estimate of a unit maximum deflux in certain determined basins of determined area remains vitally attached to the judgment concerning the safety of Rock Dams. The data, that I see given given with simple, tranquil presumption, is greatly below the possible limits of maximum deflux in the Alpine sections to which the Projectors allude. Instead of adding anything new to the theme, the "Instruttorie" refers literally, as I said, to the "Scritti Luiggi". To these I will exclusively draw your attention.

It is true that some good constructors counseled and still counsel the building of dams in the Alpine valleys that are not in fact rock fill dams, as they are said to be. Their structure is quite different in every way, being of dry masonry. It is true also that the pure type of Rock-Dam is increasing, at least on the chart of the projectors, to the most alarming heights.

Returning therefore to the "Scritti Luiggi" as the authoritative cause, to my way of thinking, of the mentioned suggestions, I affirm, (the proof following), that the first place accorded to Rock Dams does not have any real foundation or even any sufficient justification in the divers texts that speak on the subject in favor of the propaganda. Not even, which is more serious still, is there any justification for the examination of the

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technical side of the question from deductions made specially from American literature and the application of said rock construction in America. Therefore, we have an exaggerated result or one not consistent, which gives rise to a legitimate repulsion to the use of Rock Dams in the Italian valleys.

That which I think of the said dams and their too exclusive propaganda is not deducted today, but has been known for more that a year by some authorities in Rome, Milan, and Turin, and moreover it is known to the Honorable Commandatore Luiggi. But refuting any polemics, and having hoped even more to avoid them, I will say that the work I have undertaken in this paper is done for justifiable motives of convenience, because of my position in the Council, because of a deference felt toward a benevolent colleague, and also because I counted on the spontaneous reaction or discussion of the studied technical opinions. This hope has diminished, and because nearly all the best youth of cultured mind and vigorous mentality are found in other fields not less worthy of them, I meet the debate with bitter sincerity; I also meet it through a duty now indeclinable seeing the part that concerns me with a grave collective responsibility.

I feel that an erroneous information given today will facilitate a result that would quickly have dire effects on the Reservoirs of Italy that are a most important factor in the future of the country.

Another very necessary point in these notes is the clarification of all the given data, by means of clear speech and the avoidance of conventional euphemisms.

These Notes will state among other things:

a. That the technical conduct of the Scritti of the Engineer Luiggi, on Rock Dams, on account of a lack of precise references, on account of the inexactness or the non-existence of too many facts asserted, on account of the inexplainable metamorphosis of numbers and dates in arguments most

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suggestive of a favorable propaganda, leave, in whoever is in a measure to analyze things, a most unfavorable impression.

b. That there is not existing required specific information which would make of the Rock Fill Dams the only ones advisable in countries subject to seismic movements (as are said to be the only ones advisable in the high Alpine valleys). The earthquake of 1906 in California, which ruined San Francisco, did not give such indications; it suggested some quite contrary, which give rise, as a result, to some of the most important special publications on the disaster.

c. That contrarily to what can be remembered from the said "Scritti" the Rock Fill Dams, as regards the U. S. of America, have only a minimum frequency of application in the entire construction of High Dams; this not only as regards the entire U. S., but also the Western States, of which California is a small part, and where the conditions of great medium heights of the basins is more accentuated than in California itself.

d. In the same California, the type of Rock Fill Dam never prevailed, and today it is not, as we are led to believe, recognized to a point of ideal evolution, but is in a state of decided decline for High Dams, and one can say almost, that new examples are entirely lacking, while the Arch Dams, the Multiple Arch Dams, the Reinforced Structures, and even the depreciated Gravity Dam (arched base or not) are increasing and are even taking the place of ruined or formerly-planned rock-dams. Imposing gravity-dams rise at most high elevations in the immense highlands of the West.

e. That the flow capacity, capable of withstanding efficaciously all the contigencies of overflow, infiltration, and underpressure, does not exist.

f. Another point as regards the manner of breaking ---- " ---- The midfift on the upstream side will be liable to a break allowing an escape of the water in the break of the midrift of the dam will not be able to flow out at one surge but only quite slowly, and thus those disasters that occur

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with other types of dams will not happen. (G.G.C. Jan. 31, 1917 page 26.) This condition does not exist, because with the overflow, with the partial sediment, or with the breaking of the thin cemented midrift, come new elements of extreme violence, always factors in the most rapid and complete ruin.

g. That the comparisons with types in other countries must not, in any case, ever forget to consider the geographic, climatic and demographic conditions inherent to the place of application.

The United States is an immense laboratory for constructive experiments. Because of the immense vastness of its orohydrographic system as regards the density of the population, it can stand all kinds of experiments.

For a first example:

The Colorado River, whose basin of 632,000 sq. km. is 2 - 1/4 times the area of Italy, interests more or less eight states of the west, - among which are Colorado, Arizona and California, with plains at an immense height in the Rocky Mountains. This section had a population of 457,000 inhabitants in 1915 (1) But the conditions change with vertiginous rapidity, and proceeding by means of the given analysis, and by reason of a profundity practical and scientific sense, they enforce a curb through the legislation which becomes more and more severe and inflexible.

At one time there were literally undertakings or constructions which went to pieces daily. The technical journals, so as not to reduce their subject-matter to a mere chronicle of disasters, declared that they would omit the greater part and limit themselves to only the most instructive cases. The construction of reservoirs that do not stand, or of dams that crumble, is not hidden under a cloak of silence and kept from public notice until accidentally the veil is raised,but is immediately brought to the notice of the public with a sincerity that is the reason and cause of progress

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in a matter which is not stable, and in the limited knowledge that we have concerning it.

It is noticeable, also, that in France, which has a large Alpine section, and in Switzerland which is entirely situated in the Alps, there is not as far as I know any application of Rock Fill Dams. The beginning of a propaganda for their use was started in Switzerland (by Eng. Killias in the Schweiz Wasserwertschaft of 1912, Nos. 22 and 23, consequently before us) and was not followed out. The projects, as far as I know, though many are very daring, contemplating the erection at great heights of beautiful dams, consider either the Gravity of Arch-type dams, or those known as the Ambursen type.

These nations are learned with traditions that have been carefully worked out. They follow the American technique, at least as much as we do, but these nations realized instinctively the difference in the possibilities of experimental constructions in their territories, which differ so greatly in size and conformation from those of the U. S.

This reason, I repeat, is one of innate geographic, demographic, and climatic conditions. I felt this reason strongly specially in viewing the immense collection of topographic charts, and in looking through the volumes of the U. S. Geological Survey, and the Reports of the U. S. Reclamation Service, i. e. the reports gathered from 450 volumes of which I possess the greater part, from the Water Supply Papers of the U. S. G. S., a complete monography of geographic and hydraulic descriptions over an immense and varied territory, more that thirty times that of our country, and having immense general orohydrographic areas. This is combined, it is understood, with a study of the density of the population taken from various censuses of several states. This density in the valleys of the Western States is still often the hundredth or the thousandth part of that in our populous little valleys which will be interested in the placing of reservoirs insomuch as they affect their safety. (No. 2, page 31).

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In these Notes and in other places in the discussion of Rock Fill Dams, I want to say that I am not absolutely adverse to the Dams themselves.

According to my way of thinking, they could be considered favorably in some cases, and again have a fatal result if used to retain water, even in a moderate amount, in some of our little valleys. They could be used provided they were designed with extreme care, one can never definitely state, so to speak, the method of calculation, and above all, there must be allowed a great latitude in providing a flow capacity.

This is easy to state, but it is difficult for even a most skillful constructor to calculate correctly.

My decided preference for the general construction of High Dams is the Masonry Dam; -- A Masonry Dam with a single arch or with multiple arches according to the form of the gorge, the solidity and compactness of the surrounding rocks etc. In general, I prefer the Gravity Dam with an arched base, planned after careful study and using the most recent precautions as regards specially the debated subject of a possible under pressure.

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3. First Conceptions Concerning the Irregularity of the Method Used in the Propaganda --- Morena Dam, Strawberry Dam, Gatun Dam, and Lower Otay Dam.

The writings of Professor Luigi Luiggi are generally mentioned in the arguments, I will for brevity designate them as "Scritti L. L." Passing over the minor points of the chronicle and of the Propaganda, I will use others as I need them. I give here a succession of numbers in conventional use

N (1) Nuova tipo di Diga Economica per Laglu Artificiale: Diga della Biaschina, (G.G.C., January 1913, riprodotto con altro titolo negli A.I.I. May 1913.

N (2) Evoluzione delle Grandi Diglie per Laglu Artificiale. Conference published in the "Industria" No. 7 to 14 and interpolated in 1914 in the "Atti S. Schenze and A.I.I.)

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N (5) Diga di Scogliera di Strawberry in California, (A.I.I. Mar.16, 1917)

N (6) Per L'utilizzazione delle Acque en alta montagna. A conference reproduced in the A.I.I. and interpolated into the July No. 1917 and Mar. No. 1918, of the "Atti S. Acievoza. I also will refer to the "Estratto".

Particularly interesting for our work because it is more technical and keeps more to the theme, is the "Scritto N(4)" of the Giornale Del Genio Civile, Jan. 31, 1917 (1 and page 30) in which the arguments have already assumed a definite character.

Considering the character of the "Scritti Luiggi", it would suffice to mention them without submitting them to severe criticism. Other texts will be of use for comparisons in the case, because he who now wishes to cunfute, must above all greatly desire in him who listens and judges, a direct and sufficient knowledge of the texts which serve as a source of information.

In this section are stated the first and already significant proofs concerning the assertions made in (a) of the preceding paragraph. These deal with the unfavorable impression that is immedately made on the reader. In this first glance, one sees the characteristic phases of the "Scritti L.L." exhibited in various manners, which continue all through his Scritti. The scarcity of the Sources referred to shows the poor ground he has for advocating the adoption of notable recent Rock Fill Type Dams. I will prove this statement

The examples concern the two immense rock dams of Morena and Strawberry in California, the collosal Gatun Dam of the Panama Canal, the Lower Otay Rock Fill Dam in California and its destruction.

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In this section are stated the first and already significant proofs concerning the assertions made in (3) of the preceding paragraph. These deserve with the unfavorable impression that is immediately made on the reader. In this first glance, one sees the characteristic phrase of the "Scritti M." exhibited in various manners, which continue all through his Scritti. The scarcity of the Sources referred to shows the poor ground he has for advocating the adoption of notable recent rock fill type Dams. I will prove this statement.

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MORENA DAM

This dam is in San Diego County, Southern California and holds the laurels for its daring height which is 150 ft. or 45.75 meters and not 61 or 61.5 meters as the works of L. L. (Luiggi) would have us believe. In reality in his first report L. (Luiggi) indicated it as being 36 meters high, but in his second report and in all the following ones as 61 meters or 61.5. A recent notice in a chronicle (A. I. I. June 16, 1918) with data concerning the Dam of Gazza in the Enza had called attention to the fact the the Dam was 75 meters high, "being the highest Rock Fill Dam in the world as the other two highest similar dams of the Morena River and the Strawberry in California which are 61 and 56 meters respectively are far greatly surpassed by this aforesaid one." (A. I. I. June 16, 1918, page 187.) The two highest American are in reality one, 45.75 meters and not 61 meters, and the other 42.70 meters and not 56 meters. The difference in the height is great enough.

The descriptive account written by the constructing engineer O'Shaughnessy about the Morena Dam in the "Transactions of the A.S.C.E., 1912, pages 27 to 62 to which Luiggi refers continually is in truth the only work of the last decade in the classic collections of the P.C.E. which refers to the rock dams, while those referring to the masonry dams of various types are numerous. The constructor explains clearly by drawings and by numbers in the text that the Morena Dam is 150 ft. high (boc. cit. pg. 35, 36, 37, 41, 47 etc.)

It is well indicated that the wall of simple "talions" on top of the trapezium of rock descends 112 ft. (34.16 meters) to the rock under the foundation base, from which the constructor counts the 150 ft. elevation (total 262 ft. or 79.91 meters.)

Therefore when the constructor himself makes an estimate on the cost of a supposed masonry Dam he takes logically as a base the entire height;

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but there is no legitimate reason for counting the real height in the case of a Rock Dam. According to its Constructor, the Morena Dam is 150 ft. i.e. 45.75 meters.

When in 1916, the Morena Dam escaped by pure luck, (as one would say, a narrow escape, an expression which is equal to miraculous escape) the ruin which struck the Lower Otay Rock Dam, the experts who discussed the circumstances of this lucky escape of the Morena Dam and urged measures that should be adopted to make it secure, repeatedly mention its height at 150 ft. For further proof see "Eng. News" of Dec. 14, 1916 on the plans for ameliorating the Morena Dam, with the report of Cromwell to the San Diego Council, also the "Eng. Record" of Feb. 12, 1916 on the breaking of the Lower Otay Dam etc.

But this assumption of a height of 61 meters is derived from an alteration of the original drawings of Engineer O'Shaughnessy which we hold as unjustifiable; - (page 36, 37) copied in drawings 5, 6, 7 of Plate 1 Giornale G. Civile, Scritto "N" (4) and also numbers 33 & 35 in Scritto N (6)

The line which the Constructor of the Dam calls 50 ft. i.e. 15.25 meters under the base of support (a prop) of the rock construction is taken as zero in the works of L.L. The real zero elevation then becomes 15.25 meters and the top of the Dam elevation 45.75 meters (150 ft.) becomes 61 meters. And thus there is a laborious and singular new quoting of all the data given in the drawings of the Engineer O'Shaughnessy.

STRAWBERRY DAM

Here also we find a great deviation in the real height of the Dam.

The indication in Note N (4) page 13 seems exact: * "The dam is in its entire height 53.20 meters of which 10.50 m. are in the foundation under the bed of the river and 42. 70 meters are above. The statement leads to a singular misconception when the altitude changes from 42.70 meters to 53

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STRENGTH OF DAM

Here also we find a great deviation in the real height of the Dam.

The indication in Note M (4) page 13 seems exact: - "The dam is in its entire height 38.30 metres of which 15.00 m. are in the foundation under the bed of the river and 42. 70 metres are above. The attachment lends to a singular misconception when the altitude changes from 62.70 metres to 38

meters and again to 56 meters in more recent descriptions.

The midrift diaphragm that continues the wall and rises or descends to join the rock is included in the height which thus receives a great increase not really existing. The same structure of rock dam that is for example 10 meters at its plane of support would be 20 meters if its retaining wall joined the rock 10 meters under the said plane of support, - or 40 meters if it were 30 meters under - while it is evident to all that for the statistical considerations of the rock structure, the height is considered from the plane of support and not differently.

That this is an incorrect and arbitrary way of calculating the height of Rock Dams allowing elastic dilations, is proved in the same article in the "Eng. Record" of August 26, 1916, pages 260-262 from which Professor Luiggi took designs and text prepared expressly fromNotes N (5) of the Strawberry Dam, but which is not cited in the "Works" themselves nor in any other "writing".

The original text, besides its clear drawings, says moreover:- "He is constructing a dam of rock type with a skin of masonry having an impervious coating on the mountain side. A rock dam should have a maximum height of 140 ft. above the bed of the river while the cut off wall must be carried to a depth of 33 ft. under the bed of the river."

But there is another disagreeable circumstance that must be revealed. While the drawings of the Strawberry Dam are copied from the original in the article just mentioned (See figures 8 and 9, table 11 of Luiggi's "Scritto" N. 5 figures 36 and 37 of "Scritto" N. 6 and see the original drawings, page 261 in the Eng. Record) the said copies are retouched by the added arbitrary ledges, "shelves" on the ground floor and the sections.

These ledges and a few other added particulars on the floor of the valley would bring the Strawberry Dam nearer to the type proposed by L.L. in the "Scritto", - but these do not exist in the original drawings or in the construction. The "paramento" - (retaining wall) to the valley is in

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one unbroken line at an angle of 1.3 at the base for 1 in height.

It might be supposed that these additions are derived from special information given by the Directing Engineer, Howson; but without stopping for another unpleasant revelation, let us say that this is evidence gained from another source, - not the article of "Eng. Record" the only one that is used in the Scritto L. L. N (5) on the Strawberry Dam. It is in the article of the same G. Howson under whose authority the work of the Dam was executed (O'Shaughnessy being still the Consulting Engineer) which appeared five month before the other in the "Eng. News" March 30, 1916 p. 604, where the great insistence is put on the ledges, and they are clearly outlined in the drawing of the valley. This in truth does not concern a special method. As the type of the Morena Dam was already in 1913 the "ideal type", (Scritto L.L. N(1) page 8) the type of the Strawberry Dam is a more recent type of superlative perfection:- "In its entirety the Strawberry Dam represents all knowledge that 30 years have demonstrated as necessary to guarantee in an absolute manner, as far as is humanly possible, the stability of this construction even in seismic regions like those of California: at the same time reasonable and admissible in practical construction as far as expenses and time are necessar for executing the work are concerned". "And the Superior Council of Public Works conscious, as one might say, - of the importance of such works" Scritto L. L. N (5) A. I. I. page 86 of March 6, 1917.

Now we must eliminate the small frequent benches of 3 meters which break the wall to the valley at irregular intervals in the Strawberry Dam and in the type proposed by the "Scritto" L.L. - The Morena Dam has in fact only one bench of 6.45 meters half way up the Dam, made according to the most modern models.

The reason for the existence of these benches is that they supposedly facilitated the construction of the Dam (Scritto N (4) page 11) which is really not true: but for security we prefer in every case a single line - outward tangent to the broken surface.

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If there are at least 95 chances out of 100 that a Rock Dam be subject to destruction when it is subjected for a few hours to overflow from its highest point, - we claim that such a chance is augmented when the even incline is broken by several ledges.

THE GATUN DAM OF PANAMA MADE OF EARTH AND ROCK.

Besides the two dams of Morena and Strawberry, greatest on account of the boldness of their elevation, there is another wonderful dam which is presented to the world as a Rock Dam, Gatun, the dam in Panama but it is not a rock dam. In the "Scritto" L. L. N (2) the dam is said to be about 40 meters high with such gentle slopes that the width at the base is over 900 meters "formed by a nucleus of rock covered with clay.-- This can give an idea of the faith that the American Engineers have in the "Rock Dams" since they adopt it for a work as important as the Panama Canal;" (loc. cit., p. 9 to the Estratto) But the greatest argument by which he persuades us to give up all hesitation is here outlined (Scritto Luiggi N (4).

And in fact the North Americans wanting to construct the Gatun Dam, which is perhaps the most important factor in the functioning of the Panama Canal - (which will be, so to say, eternal), - adopted, as one can see, a rock dam filled in with earth as the only one safe in regions subject to seismic disturbances." (loc. cit. page 5) - and again, "The Gatun Dam is an enormous mass of rocks rendered impermeable by means of clay, by reason of its dimensions, and because of the great precautions taken so that it can resist all possible calamaties, it is certainly the most important rock dam yet constructed."

The Dam is about 40 meters high, with a maximum water retaining height of 31 meters. It thus rises 9 meters above the maximum level of the lake, thus avoiding absolutely the possibility of overflow. The slope is most gradual, at the top 5 in base for 1 in atlitude and in the valley a base of 25 for 1 in elevation. The fact, that after many years of mature study, a Commission composed of five specialists of world renown adopted a dam of

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rock foundation is the proof that rock dams used rationally and with great foresight, are those that present the maximum stability under most violent shocks such as Panama is subject to". (loc. cit. page 16, 17). The argument is used to carry decisions but it is not possible to believe the Gatun Dam a rock dam, much of the data being visibly incorrect.

The article of Wegmann, "The Design and Construction of Dams", in the same 6th edition N. Y. 1911 quoted repeatedly in the "Scritto L. L.,- gives an extensive report of this dam with drawings, the descriptions of which were expressly prepared for the edition of March 1911. This text cites Colonel Goethals (now Major Gen.) as the Chief Engineer and President of the Panama Canal Commission (p. 453 and 458). The work of Wegmann should be placed in every School of Engineering.

From the drawings it gives and from the subject matter, as well as from more recent descriptions given in 1917, one gets a very concise idea of the height of the dam. Chief among these later reports is that of "The Annaul Report of the Isthmian Commission". These all point out that the height of the dam is 115 ft. (35.08 meters, not 40 meters) reducing its highest point to 104 ft. or 32 meters. The highest water mark is 85 ft. (25.92 meters and not 31), the width at the base is 2019 ft. (615.79 meters and not 900) etc.

With these dimensions, if it were true, as the "Scritto" L. L. - calls to mind (loc. cit. p. 17) that one was dealing with a rock frame-work or "with a mass of rock into which has been infiltrated an enormous mass of clay by means of hydraulic sluicing" - the example given would make one fearful of using the rock dam for Reservoirs - be it on account of the great deviation between the top and the base - 25 meters of retention and 600 meters at the base of the construction; - or were it for the fact that the under construction - the real construction being an elevation of impervious moraine - is not that of rock dams, where according to the rule so much is insisted upon in the "scritto" Luiggi - the body of the Dam is made exclusively of rock". (See "Scritto" N(4) page 20.

rock foundation is the proof that rock dams need rationally and with great foresight, are those that present the maximum stability under most violent onsets such as Panama is subject to". (Loc. cit. page 16, 17). The argument is used to carry decisions but it is not possible to believe the datum that a rock dam, much of the data being visibly incorrect.

The article of Wegmann, "The Design and Construction of Dams", in the same 6th edition N. Y. 1911 quoted repeatedly in the "Boritto E. L.,- gives an extensive report of this dam with drawings, the descriptions of which were expressly prepared for the edition of March 1911. This text cites Colonel Goethals (now Major Gen.) as the Chief Engineer and President of the Panama Canal Commission (p. 482 and 508). The work of Wegmann should be placed in every School of Engineering.

From the drawings it gives and from the subject matter, as well as from more recent descriptions given in 1917, one gets a very concise idea of the height of the dam. Chief among these later reports is that of "The Annual Report of the Isthmian Commission". These all point out that the height of the dam is 115 ft. (35.05 meters, not 40 meters) reducing its highest point to 104 ft. or 32 meters. The highest water mark is 85 ft. (25.92 meters and not 81), the width at the base is 2012 ft. (613.79 meters and not 200) etc.

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But above all the fundamental fact is that the framework of rock does not exist because the Gatun Dam is a dam with a framework of earth.

Wegmann begins his chapter (p. 451) by saying "As regards the Panama Canal, the Gatun Dam is in construction an earthen dam of 7500 ft. in length and about 110 ft. in height." From the long report of Goethals, Constructor of the Panama Canal, in March 1911, the following extracts will suffice. "The drawings 192 and 193 show the location, the project and the outline adopted. The dam will be an earthen dyke 7,700 feet long, 390 ft. wide with the normal water line at an elevation of 85 feet, high water line at 100 ft.; the highest point of elevation reaching 115 ft. and the base at the section 2019 ft. wide (at sea level). The dam will consist of hydraulic fill between two toes of select rock 1200 ft. apart.

The hydraulic fill consists of clay and sand brought from the surrounding country. Four suction dredges with 20 inch tubes distribute the filling etc.

In figure 193 Wegmann gives every detail of the construction of the section and shows that the rock is only a small part of the total volume, and not the main framework as we are led to believe.

If the Gatun Dam was in Feb. 1911 about 2/3 of the work then being done, (according to Goethals' report) it is well for us to follow the said work in the "Annual Report of the Isthmian Canal Commission" reporduced largely in the greater part of the Technical Periodicals:-

Eng. News	Nov. 21, 1912	page	941
" "	Dec. 4, 1913	"	1123
" "	Nov. 26, 1914	"	1093

The report of 1912 is particularly interesting for the analysis of the variations and changes, sometimes serious, of this great work which went through many modifications until at last the character of the earth dam became fixed. "The reductions in height from 135 ft. to 115 ft. was decided in 1909 immediately after the displacement of the rock fill that occurred at the south toe of the Dam. Another lowering of the altitude from 115 ft. to 105 ft. is shown in the Reports of 1912 and 1913. In the most recent technica

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The hydraulic fill consists of clay and sand brought from the surrounding country. Four suction dredges with 20 inch tubes distribute the filling of the section and shows that the rock is only a small part of the total volume, and not the main framework as we are led to believe.

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descriptions on hand, those of H. Cretlow (#1 p. 134) the earth dam is 105 ft. high (32.02 meters) and is exposed to a maximum water level of from 85 to 87 ft. (about 26 meters) at which level the dam is still 390 ft. wide (119 meters).

The character of the earth dam is reconfirmed (restated) at every turn. "The dam is an earthen embankment of 7700 ft. etc. The interior construction is formed by a mixture of sand and clay, dragged in by hydraulic process. The entire dam contains 21 million cubic yards of material, (about 16 million cubic meters).

The dam therefore is of earth because it could be of nothing but earth, and not of masonry in a place having its base at sea-level, and with the earth available to a great depth: one can examine the accounts of the same sections of the ground in the Goethals Report as in the Wegmanns. Text - page 452.

This being fixed, and overlooking the details of secondary importance, if one re-reads the passages in the "Scritto" L. L. on the Gatun Dam, which make it the perfect prototype of the Rock Dam, - one gets a most peculiar impression,- especially when one realizes that the distinguished Author is in full possession of the English Language.

The writer on the other hand has a mediocre knowledge (#2- page 134) of the language,- but a sufficient one to understand with fair accuracy what is said; where the sense is more obscure as it is in a literature as full of idiomatic expression as the American, - a capable assistant clears the meaning.

THE LOWER OTAY ROCK DAM RECENTLY DESTROYED.

The recent destruction of the Lower Otay Rock Dam located on Dulzura Creek, in the same region of San Diego, Southern California as the Morena, has given rise to an important number of analyses on Rock Dams.

The analysis of certain disastrous causes (Bouzey and Austin above all) are without doubt the best factors toward progress: at least for the types

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ft. high (82.02 metres) and is exposed to a maximum water level of from 8?
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what is said; where the sense is more obscure as it is in a literature as
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THE UPPER OTAY ROCK DAM RECENTLY DESTROYED.

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has given rise to an important number of analyses on Rock Dams.

The analysis of certain disasters causes (Dewey and Austin above al
are without doubt the best factors toward progress: at least for the types

whose vitality was worthy of a real and permanent conservation.

In this case the analyses above cited tolled the funeral knell for a type never suitable even in the U. S. and that never had any great importance for frequency of application.

As for the great value of the alluded-to discussions in the problem of the Rock Dams we will return to it in a later paragraph. On the same subject the "Scritto" L.L. - give divers indications all erroneous and equivocal referring "for most important notes to the "Eng. News" of New York of Oct. 15, 1916, where are described minutely the causes of the disaster" (Scritto L.L. N (4) page 9).

This number of Oct. 15, 1916 of the "Eng. News" does not exist; the numbers having the fullest descriptions, the analyses and arguments are:

Engineering News	Feb. 3, 1916	page	263	
" "	" 10, 1916	"	283	
" "	" 17, 1916	"	334	
" "	Mar. 9, 1916	"	462	- 473
" "	Apr. 13, 1916	"	717	
" "	May 25, 1916	"	1007	
" "	Aug. 3, 1916	"	231	
" "	Dec. 14, 1916	"	1112	
" Record	Feb. 12, 1916	"	225	
" "	June 10, 1916	"	769	
" "	Aug. 12, 1916	"	195	

Even a superficial knowledge of the complete decisive arguments in the Atti 1912, American Soc. Civ. Engineers, to which the "Scritti L.L." continually refers, would have avoided an exposition of the facts, - such is the statement of the Scritto N (4) Gior. Genio Civ. number of Jan. 31, 1917 pages 8, 9, 21.

The Dam of Lower Otay in the Scritto L. L. N (1) page 7 of the Estratto, is cited as a model of its type:

Other types rational enough and acceptable, - to wit, - that of the Lower Otay Dam in California, made simply of rocks thrown together" .... became afterwards the disaster laden with faults.

(A) Above all its length of service is almost doubled.

"It was constructed in 1887". (Scritto L.L. N(4) page 8).

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Engineering news	Feb.	3, 1916	page	358
" "	"	10, 1916	"	398
" "	"	17, 1916	"	384
" "	Mar.	9, 1916	"	402 - 478
" "	Apr.	13, 1916	"	717
" "	May	25, 1916	"	1007
" "	Aug.	3, 1916	"	231
" "	Dec.	14, 1916	"	1112
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"It was constructed in 1887". (Scritto I.L. N(4) page 8).

"The Lower Otay Dam in which after more than 35 years of service" --- (Scritto N (4) page 21).

"In every way this one had given good service for many years when things occurred that completely destroyed the capital invested in it, and it was rendered possible to re-erect it at that time because it demanded a small initial expense, while they would not have had sufficient funds to rebuild it had any other type been adopted".- (Scritto N (4) page 21) (foot note).

Now taking information from other sources, - the Report of O'Shaughnessy in the said Document Am. Soc. Civ. Eng. 1912 specifies that 1887 sees its beginning as a Masonry Dam, that the minds of the owners alarmed at the cost changed the type of construction and that the Rock Dam was begun in 1894 and finished Aug. 18, 1897. The height is given as 130 ft. and in the highest section a maximum of 134 ft. (40.87 meters).

Therefore it was in existence less than 19 years and <u>not</u> more than 35 yrs. These facts were brought out in number and in writings in the discussions that took place after the destruction of Jan. 27, 1916, - so that even at a glance such a mistake should be impossible. (See Eng. News Feb. 10, 1916 page 283 - Eng. News, Mar. 9, 1916, page 462 - Notes by Sellew etc.)

The break that destroyed the valley caused an enormous amount of material damage and the loss of only 14 lives because an intelligent official, the Coroner of San Diego, had the order given to leave the Valley when the level of the water was still 4 1/2 ft. (about 1.35 meters) below the top of the Dam, the peril attendant upon an overflow being dreaded. The few victims owed their misfortune to their own imprudence.

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gravity dam in place of the destroyed rock dam.

(B) My allusion to the type of reconstruction contradicts therefore another assertion of the "Scritto L.L. N (4) "after more than 35 yrs. of service the midrift deteriorated so much that in the last year the water escaped from it, and now they think of replacing the old Dam by another more lasting with a midrift of reinforced concrete placed higher up on the slope". (loc. cit. page 21)

Let us turn again to the occurrence, - the escape of the water is an excessive attenuation of the cause of the destruction of the Dam which in a few moments opened outwards like a pair of gates after a few inches of overflow throwing into the valley an enormous wall of water that covered the first 16 kilometers in 48 minutes. (Silent, Eng. News, Feb. 17, 1916 page 335).

Thus it is said by all who describe this that the Lower Otay Dam was swept out, and not "that the water escaped nor a crevice from which grave dangers resulted as well as few victims in the valley below" (Scritto N (4) page 9).

But the most singular statement is that another rock dam is to be constructed with its midrift on the side of the mountain. One can find no trace of this in any of the American technical periodicals. Any one who follows them will find immediately that the Lower Otay is to be reconstructed in masonry, of gravity type with an arched base.

The"Eng. News" of Aug. 3, 1916 and the Eng. Record of Aug. 12, 1916 give ample notes on this very important matter.

In regard to the Lower Otay and Barrett Dams in the same section as the Morena Dam (Cottonwood Creek) in upper San Diego Co., the already well-known Constructor of the Morena and Strawberry Dams Engineer O'Shaughnessy, who was a warm supporter of Rock Dams till 1916, submitted to the San Diego Council two proposed "Gravity Dams with arched bases in cyclopean concrete" - which were accepted after the first hearing on

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July 17, 1916. See Eng. Record of Aug. 9, 1917 page 285, Oct. 4, 1917 page 669, which give the details of the contract for the new Lower Otay Masonry Gravity Dam, which was immediately begun.

(C) These facts are also cited on account of their evident intrinsic importance.

The slope of the sides are not 1:1 (loc. cit. page 8). Already in the special report of O'Shaughnessy in 1912 it was indicated that they would be slightly more precipitous 1 1/2 horizontal for 1 vertical (Report cit. page 30) but if there is in the discussion which follows any inexactness it will appear several times that the slopes are at least 1 1/4:1 (See Cromwell'sReport - Eng. News Apr. 13, 1916 - Cromwell being the Engineer of the city of San Diego).

The assertion then that "Nevertheless the Dam gave good service and possibly would still be rendering good service if an exceptional cloud-burst had not occurred during the last Autumn, the lake being full and there being an insufficient overflow area." .. (Scritto L.L.N (4) Page 8)

He has contradicted all the well-known data that is found in every account of the event.

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The note on page 283 of the 10th of Feb. 1916 Edition of the Eng. News says again:- "It is considered that in the 19 years since the construction of the Dam, the reservoir was filled to its absolute limit by the hurricane of last month that destroyed it."

In the minute description of the Eng. Record, Feb. 12, 1916, the overflow level seems to be identified with 122.8 feet. The coming of the meteor is described in connection with the rise of the lake. In 48

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hours from the 15th to the 17th of Jan. 1916 the lake rose 17 ft. reaching on Jan. 17th, the elevation of 101 ft.

The cloudburst therefore, did not find the lake full, but on the contrary 17 & 22 or 39 ft. (thereabouts) about 12 meters under the level of the overflow. This level (122.8 ft.) was reached on Jan. 21st.

The break came at 4:45 P.M. on the 27th with the water level of 130.8 ft. according to the time measure adopted in the aforesaid report there being an overflow of from 4 to 6 inches above the crest of the Dam, or from 10 to 15 centimeters.

In this paragraph we believe we have given an accurate conception of the intrinsic conduct and method of the "Scritto L.L." in examining some of the arguments that have great value in the propaganda.

Anyway the non-exaggeration of facts contained almost entirely in the Special Scritti of Technical Character N (4) of the G. del G. Civile Jan. 31, 1917 where similar analyses are reported will uphold me.

Now I come to the intrinsic value of the arguments for or against the Rock-type Dam according to the outline traced at the end of paragraph 2 of this work. This valuation is deducted from an analysis of the technical American Sources procured from the illustrated text method specially disagreeable conclusions will be drawn by the examination of the "Report of the Defense of the Rock Types" in the Istruttaria discussed by some well-meaning projectors from whom one must exact, if not official authority, at least an accurate knowledge of the subject under discussion. Instead of this, we find repeated the same errors of numbers and of facts as in the "Scritti L.L." Other errors are added to these showing definitely that these reports were prepared second-handedly, an act that is intolerable in official transactions where the public safety is at stake, and where there is an enormous responsibility undertaken.

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4. The Rock Dam in Relation to Earthquakes.
Erroneous assertions about the San Francisco Earthquake.
Essential difference between Rock and Earth Dams.
Valuable information unfavorable to this type as far as Earthquakes are concerned.

This paragraph assume the task of removing an illusion concerning the specific requisite advantage of the Rock Dam --- an advantage very precious and attractive but which does not now exist.

The illusion touches specially our lands at Calabria - Sicily etc. afflicted by earth-quakes; such illusions based on the faith in the "Scritti L. L."; these illusions are looked upon as current axions, - but the hasty credulity of the people, or their passive deference to the opinions of the author, are freighted with perilous results.

The "Scritti L. L." says "The Rock Dams are the most secure against all calamities even earthquakes; and in fact all the Rock dams constructed with sufficient slope and with necessary precaution, resisted, as experience showed, the most violent shocks of the S. F. earthquake, ("Scritto N (4) page 5.) A mass of rocks cannot suffer any appreciable damage even from the most violent earthquake shocks. It may become a little affected, it may undergo a sinking, but it will not be disintegrated, and still less will it cave in, or be wrenched apart .... This explains how the indicated precautions having been followed, there resulted constructions that resisted the violent shocks of the most serious S. F. earthquake (Scritto N (4) page 24) ... finally they can resist earthquake shocks as was well proved by the excellent preservation of the California Dams of this type even after the violent earthquake that razed the City of San Francisco to the ground "Scritto N (4) page 25).

A statement copied word for word from the Scritto L. L. N (4) with the following note as an ultimate conclusion in the most recent number of the "Annali Ingegneri Italiani" of March 1, 1918, (Scritto N page 72.)

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A statement copied word for word from the Scritto L. L. N (4) with the following note as an ultimate conclusion in the most recent number of the "Annali Impegneri Italiani" of Anton 1, 1918. (Scritto N page 72.)

"For the Alpine Valleys, or those of the high Appenines, for Calabria, Sicily or Libia, subject to seismic shocks ... the Rock Dams offer the most simple, and the most rapid, the most economical, and above all, the most secure solution even in case of earthquakes" ....

The assertion and the reference to S. F. as proof have an undeniably resolute precise sound; one would look, however, in vain for any definite source of information in the "Scritti L. L. ", (1) Already when about a year and a half ago, I began to have some doubts about the general reliability of the "Scritti L. L.", I wanted to examine more deeply the arguments that I followed at first as contiguous with others dealing with my favorite occupation. But I did not find any record in my papers correlati the California earthquake with the Rock Dams.

I had read also at the time the Article by the California Engineer O'Shaughnessy on the Morena Dam in the Documents A. S. C.E. 1912 to which the"Scritti L. L." continually refer, but in this I did not see a thing about such a correlation, not even on the value of the Rock Dams in seismic zones; which great value should have had the S. F. Engineer O'Shaughnessy resumes on page 67 of the Paper cited in favor of the Rock Dams. #2

Thus in the volyminous Wegmann text on Dams (1911), the American text par excellence, in the few pages dedicated to the Rock Dams (14 in number the same as for the timber or crib Dams) there is not a word about the essential prerequisite of Rock Dams in relation to earthquakes and still less about their definite result in the S. F. Earthquake of 1906 so clearly defined by the "Scritti L. L." The same can be said of other sources of information still more general that I have examined.

It is understood that one may express a <u>personal opinion</u> as to how a Rock dam would stand in the event of a generic earthquake. Thus easily with no effort, I have found a former writing of the same Engineer O'Shaughnessy, Constructor of a good Rock Dam, who took part in 1914 in the "Discussion on Wall and Arch Dams for Huacal, Mexico the Constructing

"For the Alpine Valleys, or those of the High Apennines, for Calabria,
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Engineer being Hawgood -- in the "Proceedings A. S. C. E. Aug. 1914 page 2031. O'Shaughnessy alluding to the menace of earthquakes, makes this remark which does not exist in the O'Shaughnessy report of 1912:- "In the case of the Upper Otay Dam, with a capacity of 1,000,000,000 gallons, situated right above the Lower Otay Dam and above the reservoir having a capacity of 13,000,000,000 gallons, the writer was always worried about what the results would be to the Lower Dam if the Upper Dam were to break through an earthquake shock".#3

This Happened in 1914. As has been said, when the cloud-burst of January 1916 left unharmed the Upper Otay overflowing by over 90 centimeters of water, ruined the Lower Rock dam, the same O'Shaughnessy put an end to all arguments of earthquake possibilities and decided to recommend for the Lower Otay a fine Masonry Gravity Dam which is already in course of construction in Southern California.

There have been other various personal opinions, justifiable because founded on contradictory statements, - or because rock dams were mistaken for earth dams: but the fact remains of the proof of the disastrous earthquake of 1906 which should undoubtedly have left some trace, to prove its decisive importance, in the American sources of information already mentioned, while such a trace does not exist at all.

It seemed to me evident that any conclusion in favor of one kind of dam or other, in regard to the value of such dams from an earthquake standpoint, should be the result of examples drawn from conditions homogeneous enough in character, as far as earthquakes are concerned, to give grounds for the deducted results. I remembered in general that the disaster of April 18, 1906,(1) had expended its greatest intensity in Central California and specially in the Coast Region where are found established several artificial lakes with notable high retaining walls. With a first-hand examination of the great amount of material, and facts chronicled, whose discussions occupied for a long time the two largest technical periodicals of the U. S., - the Engineering News and the Engineering Record after April 18, 1906, I have

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I found a special Report in the Engineering News of May 17, 1906, page 548:-

"Some effects of the San Francisco Earthquake on the Water plants and systems etc. by the Engineer Professors Gilman, Hyde, and Derleth, representatives of the Dept. of Civil Engineering of the U. C..." who recount the successful resistance of two large dams one of earth, (San Mateo Dam), the other of prismic cement masonry dam (Crystal Spring Dam) in the peninsula of San Mateo just south of S. F. terribly tried by the accident.--10° on the Rossi-Forrel scale.

Notice the Earth Dams. I will say that despite their withstanding the shock, they should not be built in earthquake centers any more than the Rock Dams. There is not a word in the Report about Rock Dams, or in any of the chronicles of the Earthquake. I found other documents more general in nature and more descriptive as to the effects of the Earthquake of April 18, 1906 on California and the surrounding regions.

One is an important work inserted in the "Transactions of the A.S.C.E., Dec. 1907, a work of 129 pages and 36 plates. "The Effects of the S. F. Earthquake of April 18, 1906 on the Engineering Constructions". It is the report of a General Committee and of six special Committees of the Association of Members of the S. F. Section of the A.S.C.E."

In report C (page 245) of the Committee for the effect of earthquakes on Water Works has taken as example in the damaged region the Earth and Masonry Dams for artificial lakes as well as other Water Works such as Distributing Towers, Tubation, etc. that are not interesting at this time.

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of the general use of Rock Dams in California is commented upon in the next paragraph.

The Special Report C conludes about the Dams with two points, 2 and 3 in relation to Water Works that I give here with the first of a general nature. (loc. cit. page 254-5).

1. In future greater attention must be given to placing important Water Works out of the most dangerous seismic areas.
2. Earth Dams accurately planned and well constructed are structures that were proven most stable and worthy of confidence by the earthquake of April 18, 1906.
3. "That Concrete Masonry Dams with a gravity section are capable of sustaining the most dangerous shocks without damage". #1

These results are repeated in the General Report.

On account of its importance in argument, for more precise information, and for the purpose of instruction, I will quote at the end of this section all the part of the Special Report on Water Works which relate to the S. F. Earthquake and concerns the dams of Artificial Lakes.

This document is already decisive, but I examined attentively also the other more general "Report of the State Earthquake Investigation Commission" on the California Earthquake of April 18, 1906 published in Washington in 1908. It is a monumental official publication in three immense volumes:- Volume 1 part 1A and 2A, and Vol. 2 and the great "Atlantic" that looks at all the manifestations of the earthquake in the State of California and on the Nevada Border.

Index 23A of the said "Atlantic" gives a resume' of the intensity of the earthquakes in every section of a given seismic region. It shows a large area of Central California as the section of maximum intensity.

This suddenly reveals that what has been said has no sense at all as far as basic deductions are concerned, for all through Southern California, where, in 1906, existed only rock dams so much praised, - the Lower Otay, Escondido etc. the seismic phenomena is negligible, (one degree of the Scale Rossi-Forel) as it is in Northern California, while in the Central part the

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chart showed 8° to 10° on the said scale.

Naturally as the Rock Dams remained indifferent to the earthquake - all the Earth dams the Gravity Dams of Masonry of the Arch dams most daringly constructed as that of Bear Valley and of the Upper Otay near the Rock dams remained absolutely unaffected by the Earthquake for they were in the zone of minimum intensity.

Abundant signs are found in the regions greatly affected. But even here, I repeat, there is not a single word about Rock Dams although there are extensive descriptions of more or less important Earth Dams and of Masonry Dams: specially that of Crystal Springs #1 which, being in the region of the heaviest shock, "was uninjured by the Earthquake, a careful examination having failed to reveal a #2 crack in the splendid structure." (Work cited Vol. 1 part 1a, page 102)

It is of special importance to note that this great dam is of reinforced concrete with Monolithic prisms, 20 ft. by 12 by 12, (6.00 by 3.60 by 3.6 meters). The reservoir has a capacity of 24, 000,000,000 gallons (91 million cubic meters.)

To be literally scrupulous, I will say that I found an allusion to a partial rock composition, but not a word on Rock Dams, in the dam dividing Crystal Lake in two parts, a dam that in 1906 was simply a terrace for walking, - the water being of equal height in the two parts of the lake, (Vol. 1, part 1a, page 102) and therefore of no official value in retaining the water.

This dam reportedm in the publication, as made of an agglomeration of rocks and earth, "was displaced but not badly injured by the earthquake". (loc. cit. page 93.)

After the authentication of the real facts about Rock Dams and the S. F. earthquake exactly contrary in sense to the assertions made in the Propaganda, this last statement gives me a chance to declare that the

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eventual tentative to establish an analogy between earth dams and rock dams in regard to the way they withstand earthquakes, being given that both serve as reservoirs, - should be admitted.

But the Rock Dams are exactly the opposite of this, especially those with a vertex on the high line of development,- a thin overlaying of wall a few decimeters in height and behind it amassed some large rocks as the Scritti L.L. recommend because "the body of the dam is made exclusively of Rock". (Scitti N (4) page 20. Mar. 1918, page 67.-- Scritti N (6) A.I.I. and also page 29 of the Estratto).

This Mural keystone, more or less delicate being broken, the body of the dam is flooded with water being pushed along at a rate of from 20 to 30 or 40 meters per second by the velocity of the wind. Water flowing at such a rate of speed will quickly disintegrate the most resistant mass of rock in a few moments. This is sufficient evidence without addition when one considers what is destroyed by a jet or current of water flowing at a rate of only 10 or 15 meters a second.

While on the other hand we find a favorable recommendation for well-constructed, monolith gravity dams, in the most glorious story ever written of seismic disturbances,- that of the S. F. Earthquake,- which one cannot even imagine without the aid of the beautiful photographs collected in the two reports of the American Engineers and of the State Commission.

There is no such recommendation for Rock Dams. In fact there is the assurance of their certain ruin under an earthquake shock that is the least bit serious. (He is wrong here Morena Dam takes shocks without damage --- O'Shaughnessy).

The alluring power of the arguments of the S. F. Earthquake have been so dangerous and attractive that the same Administrators of the two provinces who are opposed in these days to the projected High Rock Dams are opposed to this type because even if they were justly counseled (or recommended) on

account of their adaptability in the event of such seismic movement, still they have not been tried out in works of such magnitude etc.,- Contradictions not consistent with the premise: on account of the importance of the size of the work, this would be the type most worthy if the premise were exact.

Another point is the effect of such a construction on public safety.

Therefore it is noticed that in the part of California seriously affected by the earthquake, rock dams did not exist or else did not seem worthy of mention; but in earth and gravity dams there was no trace of a break.

Appendix of the Report of the "Transaction" of December 1907 in the "A.S.C.E." Vol. 59 appendix page 245.

"Report of the Committee on the Effects of the Earthquake of April 18, 1906, on the Water Works",-

The scope of the investigation used as the basis of this report, is to establish the different values of the divers kinds of dams used in water constructions, as regards their ability to withstand earthquake shocks such as those that shook the coast of central California on the morning of April 18 1906. Besides this we must draw such conclusions as will help to ameliorate the plans, intensify cautiousness, or give more faith in the use of preceding plans according as the results show they stood the shock.

In this report it will not be attempted to describe in detail or even to mention the different structures belonging to different kinds of works in use for utilizing water in the vast area so violently shaken. The first part of the work will best be fulfilled by the description of various important kinds of structures from which the Committee has reached conclusions that seem most logical.

The types of constructions considered are Earth Dams, Elevated Towers, Masonry Dams, Distribution Reservoirs, and finally Canalization.

The position of the important structures mentione from now on, and

Appendix of the Report of the "Transaction" of December 1907 in the "A.S.C.E." Vol. 59 appendix page 348.

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their position as regards the seismic movement are indicated in the table XL.

Earth Dams:- Around San Francisco there exist some of the largest Earth Dams in the world. In the peninsula to the south of San Francisco, and between San Francisco and the Pacific Ocean lying along the line of the shock and adjacent to it, are three Dams belonging to the Spring Valley Water Co. and used as a part of the Water System that furnishes water to the city of San Francisco. These are the Pilarcitos, the San Andreas, and the Upper Crystal Springs Dams.

The displacement having been along a permanent longitudinal seismic line in this region, 6 or 7 ft. in width, these dams must have been terribly shaken, especially the two which are directly in the seismic line. The Pilarcitos Dam is 640 ft. long with a height of 95 ft. It has a width of 24 ft. at the top, and the walls are at an angle of 2 to 1. It has an interior clay core of 24 ft. in thickness extending 40 ft. under the bottom down to the water-level. It was constructed in 1864-66. It is from 1/3 to 1 miles west of the line of fracture. This dam was not damaged.

The San Andreas Dam is 800 ft. long, 93 ft. high and of the same type in general as the Pilarcitos. It was built between 1868-70. The line of fracture passed through its eastern extremity at the intersection of a natural elevation which formed a part of the Dam at this point. The convulsion of the sufface was apparent for a width of 150 ft. One of the breaks, without injuring the Dam, went through a conduit made of reinforced concrete with iron rails. The wood-covered flumes that took away the overflow were crossed by the seismic line, fractured and dislodged by the general movement. The body of the Dam shows a break of 2 or 3 inches in width extending longitudinally along the central line of the whole length of the Dam. A few slight breaks occurred in the opposite direction. As there was no filtration through the Dam, the entire Dam may be considered

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as good.

The Upper Crystal Dam is about 75 ft. in height, about 600 or 700 ft. in length and was constructed in 1878. it is of the same type as the other two already described. The original size of the construction is now changed, but at the time of the earthquake the water was the same height on the two sides so that the Dam was not subject to pressure caused by the unbalanced levels.

This Dam was crossed a little to the east of the center by the seismic line and the two parts were broken leaving a space of 6 to 7 ft. The top of the Dam shows many longitudinal and transverse breaks. The first are not continuous and appear along the entire length, being specially noticeable on the sides. One is shown in fig. 1 of table 41. A few years ago this Dam was raised several ft. so as to improve the road which crosses it. It is said that the work was done with very little care, and that it would not have been used if the Dam had remained as it was. This condition and the high grade of saturation resulting from having submerged between the two sides are considered important in the formation of the longitudinal break, the walls having a tendency to assume a more horizontal position when subjected to a strong shock. One cannot determine by these circumstances what resistance the Dam would have had against water pressure, but the nature and the extent of its visible damage are not so grave as to indicate that if the Dam had really been working, there would have been serious danger of a break.

In addition to these Dams it is interesting to mention two little Dams, each one closing an extemity of a sandy depression forming the Saratoga Reservoir of the San Jose Company, placed in the Santa Cruz Hills between Saratoga and Los Gatos. The line of the earthquake crossed this reservoir and cut the two dams at right angles. At the eastern extremity of the North Dam there are found transverse breaks going across the body of the North Dam. Figure 2, table 41 shows a break along the west side of the

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North Dam. There was a longitudinal break through the Dam and quite deep on the inside of the wall. The transverse break is shown in figure 1, table 42. Although the Reservoir was full at the time , there is no sign that the water went beyond the North Dam. At the southern extremity the line of fracture passed through the Dam. A pipe of cast-iron of 10 inches seems to have been smashed. A joining at the extreme eastern end of the Dam was also broken.

These breaks of conduits resulted from the reservoir being empty and from the washing away of a considerable part of the material of the South Dam as is shown in figure 2, table 42.

On the east coast of San Francisco Bay, the Contra Costa Water Co., which supplies the cities of Berkeley, Oakland, and Alameda with water, has two Earth Dams,- the San Leandro or Lake Chabot Dam and the Temescal Dam. In addition to these, there is one of more recent date,- the Piedmont Dam. The first of these was constructed in 1874-5 and is still the highest Earth dam in the world. Its summit height in the center is 127 ft. above the ground level. On April 18 the lake made by the Dam was full to overflowing. The shock of the earthquake raised a wave of 3 1/2 ft. high which broke over the Dam. Neither the Dam nor any of its accessories were hurt. There remained, however, evident traces of the earthquake.

The Temescal, which is 45 ft. high, was constructed in 1862. This was entirely unharmed.

The Piedmont Dam is of recent construction, is 260 ft. long at the crest, 45 ft. high on the interior angle, and 65 ft. on the outer angle, with an exterior and interior incline of 2 to 1. The interior wall was protected with 6 inches of cement having a finish of Concrete instead of the usual rip-rap. The Cement was in squares with joinings of asphalt. The Dam had been completed only a few months, and had been filled for the first time. The shock that it received caused it to settle about 6 inches in the center and produced several small transverse and longitudinal breaks near one end of the Dam. There was no break in the Masonry nor in the material.

All these Dams were constructed by the simple method of stretching them in thin strata, wetting and smoothing the layers themselves with a roller. Against the outer walls of the San Leandro and Temescal Dams has been deposited by hydraulic means a great quantity of extra material. These two Dams have an interior clay core. The Piedmont Dam is constructed without any core, but on this account the best quality of material is used in the construction of the upper part of the Dam.

Masonry Dams: The only Masonry Dams that were shaken seriously in the region are the cement dams of San Mateo or Crystal Springs and the Dam of Portola or Searsville . The first is a part of the Water System that furnishes water to San Francisco,- and the second of the system that furnishes water to Stanford University. That of San Mateo is one of the highest dams in the world, its height being planned at 170 ft. with a width at the top of 25 ft. and at the base of 176 feet. Its present height is 146 ft.; its length when finished will be 680 feet.

The Portola Dam is much smaller, its height being 50 ft. although planned higher. Both are constructed with blocks made on the spot and substantially monolithic. Each one of these is situated almost paralell to the seismic line of fracture and at a few hundred feet from it. Neither one of these Dams gives any evidence of lesion at any place. It is impossible to say what would have happened, if the line of fracture had crossed it transversely at right angles as in the case of the Earth Dams already described. It seems reasonable to suppose that these would have been hit vertically and broken as in the case of the Earth Dams. Nothing worse than a gradual loss of water from the Reservoir would have happened, as the two structures were designed with abundant gravity sections.

5. Total Denial of the Assertions made in the Scritti L.L. concerning the great predominance of Rock Dams in America.

1. Special Recent American Texts.
2. The Italian Situation as regards High Dams.
3. Special European Texts.
4. Biographical References of the Scritti L.L.
5. Report of the Proceedings of the A.S.C.E.
6. Selections from the last year's "Eng. News", "Eng. Records" and "Eng. News Record".
7. Mention is lacking of the Rock Dams of Australia.

In this section I justify the conclusions c and d placed at the end of paragraph 2 of this Report.

My conclusions are opposed to the frequent assertions made by the Scritti L.L.- of the great predominance of Rock Dams in the U.S. and especially in California.

The Scritti L. L. state that Rock Dams "so common in the U.S." - "so common in North America" (Scritti N (2 and 3)

"The technical periodicals especially the "Eng. Records"- "The Eng. News"- the classic treatise of Wegmann and the important works of Schuyler and Wilson, but above all the "Documents of the A.S.C.E. of New York" offer numerous and detailed descriptions of these Rock Dams, that they have come into current use and have the absolute faith of the American Engineers more than do the Earth dams or those of Masonry." (Scritto N (4) page 6) and then

"On account of their intrinsic value this type of dam is rapidly spreading and taking the place of the masonry dams used in the past. (Scritto N (5) page 81).

The principal argument used to prove that the Engineers have unbounded faith in the Rock Dams is that, already cited, of the Gatun Dam which is not a Rock Dam.

Going further into the "Scritti L.L." in his assertions of "frequent domination of Rock Dams", as far as putting them to use is concerned,- a well known Projector asserts textually with didactic boldness, "that if one has the occasion to consult the technical reviews especially those dealing with the recession of barricades (retaining walls) it will be found,

1. Special Recent American Texts.
2. The Italian Situation as regards High Dams.
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"On account of their intrinsic value this type of dam is rapidly spreading and taking the place of the masonry dams used in the past. (Soritto N (3) page 21).

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especially as far as what is done in America is concerned, that a great number of Dry Dams are constructed instead of those of ordinary masonry". There is no hypothesis about which are circulated such assertions, in public discussions,- and also there is an excessive confidence placed on incorrect information, diffused ingnorantly in our own country.

It is true, as has already been said, that for a growing, living subject still in process of formation, there is no text however specific that can give a complete idea of the subject. But from special recent texts, one can get a slight knowledge of the subject sufficient to give an idea, near the truth, of the predominance of one type or other of Dams.

Recent Special American Texts.--- Among the American texts that I know at first hand at this time I will mention:

The volume of Wegmann, the American text par excellence on Dams brought to the date of June 1911 (6th Edition, 1911). The brief chapter on Rock Dams in the voluminous work begins:-

"Within recent years a new type of dam has come into use in the Western States of the Union".

It consists of 14 pages and gives an idea of it importance in the American mind. The thin catalogue of a few names among which the most in evidence are the Dams of Lower Otay, Escondido, Morena:- also reports a relatively high number of disasters,- (about which the reports in favor of Rock Dams say nothing),- concerning the Walnut Dam whose ruin was a public disaster, the Chatsworth Dam and the Castlewood Dam, to which can be added the East Canon Creek Dam, #2destroyed, reconstructed, and again destroyed a second time. (See Sellew, "Eng. News Mar. 9, 1916 page 462). To this list may be added the Strawberry Dam and a few others like the Relief Dam and the Middle Fork Dam, mentioned in the Report of 1912 of Engineer O'Shaughnessy and also adding the destruction of the Lower Otay while mentioning the miraculous escape of the Morena Dam and the Escondido Dam.

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very insignificant importance of the Rock Dams of the U. S.

Schuyler's text and the original book by him in 1896-97 confirm the information given by Wegmann. As Schuyler's work refers principally to California, there is proof in his work that in 1896-97 in California itself, the high Rock Dams were of relatively small importance as compared to the Masonry Dams.

I will note in another paragraph a judgment, already definite in Schuyler in 1897 #3 concerning a most important condition necessary for the duration of Rock Dams:- a splendid condition, but so difficult to apply that it was neglected, - I will not say in the destruction of the Lower Otay Dam which was already constructed in 1897, but truly in the Dam of the Morena, finished quite a bit later in 1912.

In two splendid recent American texts, so-called technical editions of recent texts on the hydroelectric plants for reservoirs, I find that in one, (Lof and Rushmore, Hydroelectric Stations edited by Wiley, New York, 1917) out of the thirty pages dealing with American Dams, one-half of a page deals with Rock Fill Dams; in the other (Hydroelectric Power, by Lyndon, edited by Mc Graw-Hill, New York 1916 of the 134 pages of notable and original character in Vol. 1 given over to American Dams, almost entirely gravity dams, or concave structure with spurs etc. the earth dams and those filled in with hydraulic fill are touched upon, but there is not even one line about Rock Fill Dams.

With a direct knowledge of American texts up to date, on the problem of dams in North America, even the beginner must have already made up his mind as to the influence of the propaganda of the "Scritti L.L." among us.

"The Italian Situation on the Subject of High Dams."

Even the European special texts are not so backward and badly informed as to give a false opinion about the actual American technique on High Dams. In the past there were but two works on Dams, one of Crugnola 1883 and one

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and one of Torricellit 1885, which were opposed to each other in many ways, #1

The Author hopesthat in the future Italians will publish only works of the utmost accuracy and that they will get all their information at first hand. Having a knowledge of the tongues foreign works are written in, becomes an absolute necessity. They must disseminate their knowledge through public libraries and conferences.

The future Italian work must be rendered with integrity and technical capacity, with elaboration first hand and with a direct knowledge of the situation of the many questions connected with the dams. It shall be a very hard enterprise of great persistancy worthy of the efforts and of the spirit of young men who will study and manage the art with courageous and clear understanding and will know how to join or to match the genius of the method and have the patience for the analysis.

First of all, they should make themselves masters of hardship, according to the expression of the renowned teacher Carduci. We are sure that the coming future will give to us, and for us modern and organic treatise upon these great dams. In the meantime, we should be satisfied with the partial knowledge upon questions more effective. Briefly, while it would be very useful to have some technician who have familiar contact with the language make careful translations and clear resume' of the argument, we should with the experience thus in our hands not lament over the repeated propaganda. With the sketches of the designs which the one concerned should procure by all means in the foreign text that can be procured, these last designs should be displayed in the libraries of the schools and the colleges of the engineers in the Electric, Technical and among the Constructing Societies. At least, until we shall have an Italian text worthy of the subject. Such methods of diffusion (false scientific) can certainly strike the public not familiar with the facts to which I allude. But, such public do not peason,- what is worse, know nothing of the subject. As would happen to me by misfortune an examination would be brought to me and I would fail.

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One speaks of a subject in a careless way because lacking the data which technical and scientifical collaboration would provide from those who have overtaken or grasped the technical or scientifical point of view; the altenative is a useless variety and sometimes harmful to the country when one is informed in incorrect methods.

"Special European Texts".

Turning from this reflection on the Italian situation in regard to Dams, let us turn to European texts that treat of American technique and we will find:

That the text of Bellet (1907), a little backward, but which considers the new American Dams, gives only a few lines (on page 28) to the Rock Fill Dams:

That the ample text of Zeigler (Talsperrenbau 1911) gives to the same subject only a few lines found on page 121;

So also the Mattern--Rohbock (Talsperrenbau 1912).

The large, splendid work of Ludin (Wasser Krafter, 1913) work produced from great collaboration which devotes page after page to a few thousand references to American literature on Dams, makes an allusion to Rock Fill Dams (pages 1033 and 1037) with the three or four usual names, Escondido, Lower Otay, East Canon and Pecos.

A workof great size, Engel's Handbuch des Wasserbaues, (1914) names only the Lower Otay (page 621).

All these special European and North American texts must be in accord to distort the truth when they show how relatively unimportant the Rock Fill Dams are, compared to all the others, if the opposite is true that is found in the "Scritti L.L." and in those that use the latter as guides.

The Biographical References of the Scritti Luiggi.

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the collection of newspapers Eng. News, Eng. Record, Eng. News Record that there was in Oct. 1917 and above all the Atti (contract) of the A.S.C.E. according to the recommended determinations of the Scritti L.L.

One should notice in the first place the fact that this perseverance but common recommendation searches the already mentioned collection of periodicals, that is, newspapers which do not come out concerning the fundamental and general treatise which are one continued repetition quoting, also many times in the same scritto.

"See Atti A.S.C.E. 1912". It is said already the Scritto N 3 page 10 of the Estratto.

"See Atti A.S.C.E. 1912". It says the Scritto L.L.N. 4 which is founded on page 7.

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He who has eagerness or aims to study retrospective to have more information on this question can consult the article of the A.S.C.E. 1912 which is the same as Scritto N 4 page 21.

"See the Scritto N 5 page 82 for the writing from A.I.I. Mar. 16, 1917

Also in the last No. 6, always referring to Rock Fill Dams, "the most economical and the most secure against all eventualities of seismic shocks" he refers again, as he always does, to "Documents of A.S.C.E. number of March 1, 1918. A.I.I.

In all the other Scritti there is one other special reference (Scritto N (4) page 9) to the "Eng. News" Oct. 15, 1916, about the Otay Dam, a reference non-existing as has already been shown; and there is another to the "Eng. Record" of Sept. 9, 1912 for a Dam of Clay and Rock.

Enough said:

Report of the Proceedings of the A.S.C.E

Therefore if one wants to get a complete and direct knowledge of the whole argument he will be led from the Scritti L.L. to the Transaction or Proceedings of A.S.C.E. 1912, where he will find only the Report of

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Engineer O'Shaughnessy on the Rock Fill Dam of Morena, a report with which the Scritti is not familiar as is shown clearly by their report on the Lower Otay and on the same Morena Dam in regard to earthquakes etc. Now this report of O'Shaughnessy and Correspondence relating to it, making up a synthesis of all the modern doctrine on Rock Fill Dams, is an excellent special monograph on the Morena Dam, however slightlyit is glanced at from the general point of view.

There are, besides the above, three most important reports on Masonry Dams in the "Transactions" of 1913:-

The first on the treatment of the under support of Masonry Dams promoted by Harrison and on the pressure of ice against the reservoir dams:-

The second: The important report of Houston and the discussion relating to the Halligan Reinforced Concrete Dam:

The last, an important Report by Parsons on the calculation of the strength in reinforced concrete dams.

Anyone who looks through the Proceedings or Transactions for the last twenty years, and in the "Annales des Ponts et Chaussees" which every Engineer should regard as a masterpiece of his art, will find only the modest little writing of 1912 which refers to Rock Fill Dams, while he will find many important studies on Masonry Dams. After 1912, there is a profound silence on Rock Fill Dams while there are added works on Gravity Dams, on Reinforced Concrete, or Arch Dams on Multiple Arches, and most notably in the most recent number of May 1918, the works of Jorgensen on a Dam with a constant angle arch. I gave the date 1910, because I consider a space of ten years as long enough to fix approximately the technical situation of a given argument.

Finally the conclusion is convincing as to the poor amount of data on Rock Fill Dams disclosed by an examination of the index to the Tranasctions of the A.S.C.E. for the two periods 1901-1907, 1867-1901

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The Reports of the Proceedings of A.S.C.E. give a broad insight into the application of the given principles: to dam construction: i.e. Take the Arch Dams in one report of 1914 on the Arch Dams of Huacal; we find in the text discussion and valuable statistics which bring out the peculiar application of this type of Dam to North America.

Besides this we have the weekly numbers of the "Eng. News", the "Eng. Record", and the "Eng. News Record", which by their articles and their technical data, and by signaling any new fact or notable construction, gives us as we glance through the reports of a few years, the exact number and the different kinds of High Dams used in America.

In looking through the numbers for the last five months, I did not succeed in finding anything about notable new constructions except the single one of Strawberry Rock Dam which in 1916 was not advanced in construction, and of which there is nothing more in the periodicals, but of which I have learned through private research. I will add the following:

A small dam of rock fill, 13 meters high (43 ft.) with a nucleus of masonry and earth (Eng. Record, Dec. 25, 1915). A modest dam of 65 ft. (about 20 meters) in Goose Lake Valley, Oregon, that is not properly speaking a rock dam, but a Dry Rubble Wall on a solid rock foundation, as are all American Dams. (Eng. News, Jan.18, 1917. A modest temporary beam (not dam such as we are here considering) over the Colorado River. The Government of the interested States refused for five years to grant permission to construct the crossbeam of rock, only the temporary permission for which was given on account of the difficulty of constructing because of the existing water conditions of the River. (Eng. News Sept. 28, 1916, page 622.)

I have looked, as I say, with utmost care from June 1913 in the "Eng. News", "Eng. Record" and the "Eng. News Record" because the construction of new Rock Dams interested me on account of the difficulty of getting information concerning them, and I should be very happy if some one could

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A small dam of rock fill, 15 metres high (45 ft.) with a nucleus of masonry and earth (Eng. Record, Dec. 28, 1912). A modest dam of 65 ft. (about 20 metres) in Goose Lake Valley, Oregon, that is not properly speaking a rock dam, but a Dry Rubble Wall on a solid rock foundation, as are all American Dams. (Eng. News, Jan.18, 1917- A modest temporary Dam (not dam such as we are here considering) over the Colorado River. The Government of the Interested States refused for five years to grant permission to construct the crossdam of rock, only the temporary permissio for which was given on account of the difficulty of constructing because of the existing water conditions of the River. (Eng. News Sept. 28, 1916, page 522.)

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enrich the meager data of them with significant additions; which data is becomming less and less in regard to the entire construction of High Dams specially masonry dams.

As a conclusion, I will say that it seems to me to be a great exaggeration in favor of Rock Dams to say that 1 out of 100 is their proportion.

I will cite other notable cases that will serve to judge other unfounded assertions, like the preceding, in the propaganda of the Scritti L.L.; - about the placing of gravity dams among the dead timbers, about the use of great altitudes etc. I will be more specific about the references for the last years, for which I can get exact information from the chronicles.

The immense Arrow Rock Dam of Oct. 17, 1915, and which cost almost five million dollars, is a gravity dam with an arched plane made of Cyclopean cement. It is 348.5 ft. (106.39 meters) high, on a rock foundation of 250 ft. (76.25 meters) along the course of the dam. It is in Idaho, a Western State, at an elevation of 3200 ft. (almost 1000 meters). (See Eng. News Record Sept. 20, 1917. Eng. News Oct. 7, 1915, and Eng. News Jan. 16, 1913).

The large Elephant Butte Dam finished May 13, 1916 is 304 1/2 ft. high (92.87 meters) on it foundation and 203 1/2 ft. (62.08) M. on the bed of the river. It is a Gravity Dam. It is at an altitude of 4, 141 or 1350 m. (Eng. News May 18, 1916) June 19, 1903, Jan. 16, 1913. It is situated in the western state of New Mexico.

The large King's River Dam, located in the San Joaquin Valley, Calif., according to the project of the U. S. Reclamation Service will be 305 ft. high (93 m) is a Gravity Dam with an arched base situated in the highest region of the Sierra Nevadas between 5000 and 14,000 ft. in elevation. At the present moment I have not the precise height and cannot find it in the "Eng. News" of Jan. 18, 1917, pages 1.2.3) and in the Reports of the U.S. Reclamation Service.

The "Three Miles Falls" is an immense Dam of multiple arches in the mountains of Oregon in the Far West (Eng. News May 27, 1915).

The Dams of Gem Lake and Agnew Lake of the same type at an altitude of 9,050 ft. (about 3000 meters) are also in Calif. They are constructed of reinforced concrete, finished in Nov. 1916. (Eng.News, Dec. 21, 1916).

The new dam in Bear Valley of multiple Masonry arches is at an altitude of 6743 ft. (2044 m) is also in Calif. (Eng. News May 18, 1916)

Of this same type in California, and of great height, is the Tule Lake Dam, (Eng. News, April 30, 1914).

The article by Eng. Bowen, most important for the discussion of sedimentary deposits in reservoirs, in the Eng. Record of July 26, 1917, gives incidentally, information about a recent Gravity Dam (120 ft) with an overflow ad. lib. (Overflow type -- a type which is spreading in North America), in the Tuolumne River section in the Sierra Nevadas, California, at the extraordinary altitude of more than 9000 ft.

The large Spaulding Dam is a most recent Gravity Dam of concrete in the Sierra Nevadas, Calif. at an altitude of 4680 ft. (about 1500 meters) with about a height of from 225 ft.to 260 ft. (7930 m.) (Eng. News Record, Aug. 9, 1917. It will reach an altitude of 325 ft. according to the plans. Eng. Record Aug. 9, 1913).

Other important Gravity Dams with arched bases are also in California. The Big Creek Dam in the Sierras at an elevation of 6,910 ft. (about 2100 m.) will reach a height of 115 ft. from the river bed,- constructed in Cyclopean cement. (Eng. Record, Jan. 10, 1914).

The Klamath River Gravity Dam, arched base, rising 130 ft. in a most elevated region of northern California. (See Eng. Record June 7, 1913).

The White Salmon River Dam, 125 ft. high, a Gravity, arched base Dam in the highesy region of the Far West (Wash.)(See Eng. Record Oct.11, 1913.)

The Eng. News Record of Aug. 9, 1917 gives notice of another dam of multiple arches, in reinforced concrete of Rock Creek, Northern California, at an elevated altitude.

The Eng. News of Aug. 17, 1916 gives notice of the immediate construc-

tion of a big dam about 250 ft. (75 meters) in the Grand Canon, Colorado with the information that it will be either of cement or masonry. So also the Eng. News of July 30, 1916 speaks of the Hetch Hetchy Dam, 300 ft. high (91.5 meters) in the high mountains for a new reservoir which will furnish water to San Francisco, California.

The Jadkin River Dam of Carolina is a Gravity Dam with an over-fall of 169 ft. (Eng. News of Nov. 16, 1916.)

Eagle's Nest Dam in the Cimarron Valley (New Mexico) is an arched Cyclopean concrete construction. Its height is 140 ft. It is at an elevation of more than 6000 ft. (Eng. News, Jan. 11, 1917 and Eng. News Record, Dec. 6, 1917).

Salmon Creek Dam (California) is an Arch Dam with a constant angle (Eng. News, Mar. 11, 1915). See the Reports already mentioned of Jorgensen in the P. C. E. of 1915 in which many other dams of new arch type are mentioned.

The State Projects for the Reservoirs of West Fork in San Bernardino County, California (Report of the Board of Supervisors of San Bernardino Co.) contemplate the erection of a large Gravity Dam in one of the highest regions. (Eng. News Record June 24, 1918).

Another Arched-Gravity type is that of Union Gap near North Yakima, (Wash. Far West) a section of great height where they show that it will take 7,271 cubic yards of cement. (Eng. News Record, Aug. 16, 1917). A new dam of multiple arch type serves the Salt Lake Aqueduct. (Utah, Far West). It is 145 ft. high (Eng. News Record Mar. 7, 1918) and at a great elevation. Another new dam of arched masonry type for the aqueduct itself is that of Big Cottonwood Canon at an elevation of 9,456 ft. (2,850 m.) (Eng. Record Sept. 9, 1916).

The Eng. News Record recently points out that the Multiple Arched Reinforced concrete type of dam is growing in the west. (Eng. News Record March 7, 1918).

tion of a big dam about 280 ft. (70 metres) in the Grand Canon, Colorado with the information that it will be either of cement or masonry. So also the Eng. News of July 30, 1918 speaks of the Beton Metody Dam, 800 ft. high (91.6 metres) in the high mountains for a new reservoir which will furnish water to San Francisco, California.

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The Eng. News Record recently points out that the multiple Arched Reinforced concrete type of dam is growing in the west. (Eng. News Record March 7, 1918).

The construction of concrete dams must be very great because the Amburson Co. shows that it alone has constructed 100 concrete dams. Eng. News Record, June 13, 1918, page 105 of the advertisements.

The same number of E. N. R. June 13, 1918 advertise a house that handles auto-cars for construction purposes, speaks of the construction, on the Pitt River near the Big Bend in the mountains of Northern California, of a giant concrete dam costing $17,000,000 by the Pacific Gas & Electric Co., showing in the annexed photograph 30 auto-cars transporting material up the difficult steep incline of the Pitt River Mountains.

I have maintained this long quotation particularly of cases in the Western States, and more particularly in California which is but a small fraction of the same, for the evident purpose of comparing them with the Scritti L.L. well put together in Section N (4).

The passage quoted from Wegmann says that the Rock Fill Dam type is the type born in the Far West: in fact no example can be found of its application to recent constructions outside of the Far West.

Information is lacking on the Rock Fill Dams of Australia.

The American Technical Papers that give ample notice of any notable constructions in other sections where the English language is used, speak often of Australia: but I have found no mention of Rock Fill Dams in Australia.

In the Scritti Luiggi (N (4) page 16 and in the notes) the subject of the projected construction of the California Sugar Loaf Rock Fill Dam is often mentioned. Begun in 1914, and stopped on account of the great suspense caused by the War, shows how this type of construction is spreading.

This project of the Sugar Loaf Dam, according to direct reports was burried as soon as started. It is notable that the Dam itself and the diffusion of the Rock Type Dam have left no trace, even in the American Papers which would gladly have mentione the exploitation of a California type of construction.

I find instead for Australia:-

There is a great State Project (by the Conservation and Irrigation Commission) for New South Wales of a Cement Reservoir Dam in the Upper Murray Section (Eng. News Record, May 31, 1917, page 437).

The magnificent Brisbane Dam in Australia begun Dec. 1916, is 125 ft. high is a Gravity Dam of Cyclopean Concrete. It is in the mountainous region of Cabbage Tree Creek and with the accessories costs 838,000. It is fully described in the Eng. News Record of Aug. 9, 1917 page 248.

This paragraph of direct quantitative evaluation does not pretend to be statistically perfect: such perfection does not exist as he well knows who undertakes such research. But kept within the most accurate bounds possible, this paragraph is a severe criticism of affirmations in the Scritti L.L.- and in works derived from them, that the Rock Dams predominate in America and that Gravity Dams and others are a dying type etc. One can not be indulgent in words that deal with this matter, but there is no wrong intended. Instead we have profound sorrow when we think of the method that was employed and of the weight it carried in the construction of Dams.

In fact such deviation from the truth, - more fantastical than the California stories of Bret Harte have become among us (the Italians) of real technical value, as shown in the daring of quite a number of projects that have reached this office.

6. The Construction of High Dams in the Work of the U.S. Reclamation Service.

The Orohydrographic and Demographic character of the Far West and the insignificant use of Rock Dams for Reservoirs.

Legislation in the U. S. that affects Dams.

Recent Consequences.

There is in the U. S. a recent governing institution, the U. S. Reclamation Service that took the initiative in the Reclamation Act of 1902, which proposed, in the interest of the Public, to construct large

I find instead for Australia:-

There is a great State Project (by the Conservation and Irrigation Commission) for New South Wales of a Cement Reservoir Dam in the Upper Murrey Section (Eng. News Record, May 23, 1917, page 937).

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Recent Consequences.

There is in the U. S. a recent governing institution, the U. S. Reclamation Service that took the initiative in the Reclamation Act of 1902, which proposed, in the interest of the Public, to construct large State plants for irrigating the arid lands of the West, that looked after

the motive force used etc.

In a few years up to June 30, 1917, the cost of construction amounted to 123 millions of dollars spent intelligently to irrigate an area of nearly 1, 800, 000 acres (page 45).(An acre equals 0.405 hectares) with an imposing hydraulic power.

The Reclamation Service took for its exclusive field of operation the western states of Oregon, California, Nevada, Utah, Colorado, Wyoming, Arizona and Montana.

In 1900, these States had a total population of 4, 091, 000 #2 (2p 45) for an area of 3, 076, 000 square kilometers, - eleven times the area of Italy, - with an average of 1.3 inhabitants per kilometer, which is the hundredth part of ours. But this number is still far from giving a real idea of these valleys for the reservoirs were placed even in the deserted or thinly populated valleys that had a great orohydrographic value. The altitude of most of these places was great, being estimated at more than 1500 meters. It was like an immense, high island that had in itself and area about 1500 meters about 1/2 of the entire area previously mentioned, and about 5 times the area of our country.

The real idea of this Country is found in the Annual Reports of the same Reclamation Service and in the publications of the U. S. Geological Survey that illustrate the Geo-hydrographics of any part of the American Country. These reports show the said fields of work and those where our orohydrographic works are placed, - also the slight little secondary or tertiary valleys that need our reservoirs where at distances relatively short, are found little villages more or less thickly populated.

Hiere I will limit myself to Storage Dams for artifical reservoirs as distinguished from the Diversion Dams such as the U. S. Rec. Service constructs in immense, almost deserted regions. The extraorddinary elevation at which the most remarkable arched masonty dam in the world, the Roosevelt , East Park, Arrowrock, Sun River, Pathfinder, Elephant Butte, Shoshone,

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King's River, etc. are placed, is marvelous. For Storage Dams of less prominent size, many earth dams are used, but planned with great skill, with stately dimensions, and carried out with great care. Those of Rock which already existed and which came within the irrigating system of the U. S. Rec. Service are relatively insignificant,- The Minidoke Dam 25.8 meters,- the Clear Lake Dam 10.00 meters,- others of mixed earth and rock, not to be confounded with the pure rock type, which is analyzed here such as the Tieton Dam so important in construction.

I rely entirely upon the index of the Storage Dams page 453-454 in the last Report of 1916-1917, and on the Report gotten from the Reports themselves But the most daring construction, as regards height of the Retaining or Storage Dams is usually of some masonry construction generally of the Gravity type with an arched base.

I must be satisfied with this rapid glance at the U. S. Reclamation Service Article which really merits a good deal of consideration. It seems to me that the work of the U. S. Reclamation Service is an indication of the calm reflection of a very erudite people.

There where the canon areas end and where the highlands are practically deserted, as compared to the little table-lands of our country which are so full of life at every turn, the important dams are of masonry having an air of security and permanence. It is probably because they expect, as Carnegie predicts, that in a short time there will be a billion inhabitants in the United States.

As far as the construction of dams is related to public safety,- the postulate conceives only structures of an absolutely permanent nature and has no use for structures that will last only a relatively long time.

Certainly, as I have already said, just the simple knowledge of geographic and demographic factors made it possible in the past and explainable up to a certain point, that certain public enterprises and some private citizens, stimulated to boldness by lack of conscience and by the

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mania for money, (which is unscrupulous in all countries) should have made faulty dams and constructions. Then, indeed, the type of dam constructed does not matter, for the Gravity Dam, the Arch Dam, the Reinforced etc., all become destroyed, if they are constructed on faulty plans,- or are constructed fraudulently or carelessly on good plans.

In the U. S. almost immediately and still today, is felt the effect of that period of absolute license when Construction Societies and Individuals could construct Dams without any legal restraint.

I omit here all quantitative analysis of the destruction of dams which would require more space than this Report fills, but I will note that in one rainy season in the Spring of 1912, eighteen dams collapsed in the Eastern States, besides a few in the Autumnal rains.

The Eng. News of Nov. 21, 1912, states, "These are exceptional cases, but hardly a day passes when some article concerning the destruction of a Dam is not sent to this office. We are convinced that taking it all in all, there is more carelessness of engineering in the drawings and construction of dams than in any other construction. There results a greater damage to property and greater loss of life from such carelessness than results from all the carelessness found in all other kinds of construction taken together.

Hardly had these facts been brought to the notice of the U. S. Government when the latter passed a legislative measure governing the construction of future dams and ordering special vigilance measures for the dams already constructed. Such laws have often been added to by the State Departments of Engineering, as, for example, may be seen in the Report of the Joint Committee, State of New York, 1912, from pages 933-950 where is given the legislation in several states of the Union; The Eng. Record Jan. 6, 1912 for a glance at the legislation on Dams in some of the other States of the Union; the Eng. News of June 27, 1912, for the greatest demands of the Conservation Commission in the State of New York; The Eng. News, April 6, 1916 where the Pennsylvania Water Supply Commission announces more severe

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rules in addition to those of the Law of 1913 passed by the State of Penn.; the Engl News, May 28, 1917, the vigilance of the State of Connecticut in regard to Dams. And thus though it is a little arduous, one can get an idea of the approximate situation of the laws in the U. S. of the Union in regard to Dam Construction.

These laws are felt even in the States of the Far West where lately even more rigorous ones have come up.

In the State of California, the California Reclamation Board, adding to the already severe law of 1915, considered insufficient as regards Dam constructions, adds:

"The Reservoirs, as regulators of water necessary, or as means of hydraulic power, or as a means of holding water for aqueducts are sources of potential grave danger for the inhabitants and for the property situated below the Dam. Such a Reservoir gives rise to a most dangerous peril. If the dam should break, the downward flow of the water that would be precipitate into the valley below in a few hours might be ten or twenty timesthe normal maximum, an increase sufficiantly great to realize it as destroying life and property. The Reclamation Board asks special powers and special laws that wil sanction the putting into jail any one who through carelessness or through desire of gain violates the law and places in peril the lives of people in the valleys below the dam as well as the property in the same valley."

The Department of State Engineers in California, insists on specifying even more severe punishment. They show that the law of 1915 compelling the use of perfect plans is not enough. They point out the fact that a large Constructing Firm was constructing in such a way that the work was defective, and imperilled the lives of hundreds of persons living in the valley below the dam. I recall two clauses that are as follows:-

1st. That all Inspectors working for the State Engineers must make a complete and exact report on the quality of work done, and the progress of the work done on the Dam over which the Inspector has charge. Any false report shall be considered by law a felony".

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Urges Better State Supervision of Dams.

California with an area of 410,000 sq. kilom., almost 1 1/2 that of Italy, had in the last half of the century a population of 185,000 thousand in 1900 - 1, 485,000 (a density of 3.6 to the sq. kil.) and in 1910 had 2,378,000 (5.8 to the square kilometer).

The result of State interference were quickly and easily seen. In the last years there has been a great advance in the kind of work done by private individuals in the construction of dams. The technical periodicals describe plans under consideration, and work in course of construction by firms and by private enterprise that are of as great and solid construction as the work done by the State. The State interference is visible even in the most desert regions, as may be seen by the chronicle in the "Eng. News Record" Aug. 2, 1917.

A rancher of the Far West had started, in a small mountain pass of his ranch, an arched cement dam with peculia modifications of his own. The Water Master of that district suggested that he consult an engineer, and then obtain the approval of the State Engineer. The rancher responded that from the solitude of his ranch, that he had constructed a cement stable in Spokane, and that no yellow-legged engineer could teach him how to construcd a Dam.#1 The Water Master had him arrested. A few days later, the Dam which was not far along in construction, was swept away by an increase in the flow of the water in the creek where the dam was situated.

I quote at last from the publication of Lof and Rushmore "Hydro Electric Power Stations", New York, 1917 from pages 88 onward, the following:-

"Genreal Inherent Regulations from Plans of Dams for the State of New York by the New York State Conservation Commission" which I have a reason for remembering as being of 1917 at least not before 1916.

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They are general regulations but as a whole, even in my translation, which is a little superficial, they are full enough of instructions to give an idea of the severe punishment given to those who take any peculiar license with plans for the construction of dams.

Among the most evident points I will refer only to these:-

That the New York State Conservation Commission exacts the presentation of complete plans, examines the calculations in a centralized way, undertakes a first cisit to the places selected, and after the preparation of the base of the foundation, as well as during the course of the construction, assuring to the State and to the Public a thorough and competent examination of all points of construction,- and above all enforces a uniform law which is the only conceivable requirement for such undertakings.

That in the State of New York the winters being as severe as those of our Alps, (See special Reports of U. S. Weather Bureau) serious notice must be taken of the ice-pressure which reduced the capacity of the Reservoir to about 1/2 or less,- that much being all that can be useful in winter,- for the Dam cannot be counted on under these conditions.

It is from these comparisons of a climate resembling that of the Alps for the severity of its winters, that I want to take data to form normal deductions as to the effect of ice on the Dams of the Alpine Regions,- statistical effects concerning Dams in general, and specially dangerous on the layer of cementation in a supposed Rock Dam.

The laws deal with Cement Dams, Concrete Dams, Earth Dams, those of hydraulic fill, small Crib or Timber Dams filled with rock,- but they are silent on the subject of Rock Dams unknown in application outside of the Western States, where, let us state, their use is relatively small in the High Dam Type.

General Rules Governing the Plans for Dams in the
State of New York.
(Given out by the N. Y. State Conservation Commission).

They are general regulations but as a whole, even in my translation, which is a little superficial, they are full enough of instructions to give an idea of the severe punishment given to those who take any position licenses with plans for the construction of dams.

Among the most evident points I will refer only to these:-

That the New York State Conservation Commission execute the presentation of complete plans, examines the citizations in a centralized way, under a first visit to the places selected, and after the preparation of the dam formation, as well as during the course of the construction, assure to the State and to the Public a thorough and competent examination of all points of construction,- and above all enforces a uniform law which is the only compulsory requirement for such undertakings.

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General Rules governing the Plans for Dams in the
State of New York.
(Given out by the N. Y. State Conservation Commission).

"The complete plans with the elevations and the sections of all proposed Dams must be submitted and approved by this Commission before any work whatsoever can be undertaken on the dam. The location must also be examined and approved by this Commission both before and after the plans are made."

Base of the Foundations.

The Dams must be constructed on a solid bed compact, impervious, and suitable for a foundation. From such a foundations must be removed all matter subject to deterioration. The "ground" base must be fixed and drained with trenches. The wall must be carried down into the solid rock at the base and sides,- wherever possible sufficient indentations will be cut into the rock to assure a solid hold for the Dam itself. The Rock foundation must be freed from all hidden matter. For a distance of 200 ft. above the top, and 100 ft. below the surface level of the Dam, all cracks must be carefully filled with concrete, or with grocet; besides this the entire surface of the dam must be washed. Masonry Dams, more than 35 ft. (about 10 meters high), must have the rock base perforated and tested with compressed air for any hidden fissures; these holes must be filled with compressed cement under a pressure equal to the ultimate pressure.

Calculations:

The Dams must be stable in every section and under all conditions. The pressure on the Masonry of the upstream face shall be 10-14 and 18 tons per square foot, according to the Dam.

The first number (10) is for walls of less thickness than 12 ft. and for buttressed dams. The last number (18) is for dams of compact masonry rising to a height a little above 150 ft. (about 45 m); the whole executed as pe rfectly as possible under the direction of a competent engineer whose nomination shall be approved by this Commission. The cement must all be of Portland "quality" and must respond to the standard set by the laws concerning construction in New York City; it must be tried out as the

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Calculations:

The Dams must be stable in every section and under all conditions. The pressure on the Masonry of the upstream face shall be 10-14 and 18 tons per square foot, according to the Dam.

The first number (10) is for walls of less thickness than 12 ft. and for buttressed dams. The last number (18) is for dams of compact masonry rising to a height a little above 180 ft. (about 45 m); the whole executed as perfectly as possible under the direction of a competent engineer whose nomination shall be approved by this Commission. The cement must all be of Portland "quality" and must respond to the standard set by the laws concerning construction in New York City; it must be tried out as the

A.S.C.E. prescribes; any empty spaces must be filled with the proper proportion of sand and rock. The sand must be clean and of the best quality,- and the rock used for cement must be healthy, resistant, and hard,- and not easily split or broken.

Vents:

All the Dams shall be provided with outlets of sufficient dimensions so situated as to permit the retained water to be freed when it is desired or necessary; every precaution must be used to prevent any leakage through the said outlets.

Pressure of the Ice:

From Dec. 1st to March 15th no dams shall have more than 2/3 of the height of the Dam itself filled with water,- unless the Conservation Commission has given permission to keep the water at a higher level. All Dams that are liable to be full during the stated winter period must be so calculated (constructed) as to resist the ice pressure in addition to the water pressure. All Dams not planned this way must have a free outlet 2/3 of the distance up the Dam.

Foundation:

All the outlets and overflows of the Dams must be provided with drains (platee) or other structure on the valley side of the Dam, so that any damage to the Dam from the downfall of water may be prevented.

Wooden Dams:

Wood Dams can be used only for temporary construction, or where the amount of water in the lake does not reach over 30 ft., or where the depth of the reservoir is not over 10 ft. The wood of the Dam must be renewed every five years unless a permission is granted by the Conservation Commission for a longer period. The crib-work of wooden dams must be made in pockets not more than 8 ft. square, and well held together with cross-beams or bolts or not less than 3/4 in. and long enough to pass through three layers of wood; the pockets must be carefully packed with stones.

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Foundation:

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Wooden Dams:

Wood Dams can be used only for temporary construction, or where the amount of water in the lake does not reach over 50 ft., or where the depth of the reservoir is not over 10 ft. The wood of the Dam must be renewed every five years unless a permission is granted by the Conservation Commission for a longer period. The crib-work of wooden dams must be in pockets not more than 8 ft. square, and well held together with cross-beams or bolts or not less than 3/4 in. and long enough to pass through three layers of wood; the pockets must be carefully packed with stones.

The upstream face of the Dam must be built at an incline of 3 horizontal to 1 vertical. It shall be covered with a bulkhead over which shall be spread an abundant layer of gravel or coarse sand. If the foundation is of rock, the wood must be placed securely in the rock itself.

Earth Dams:

The upstream half of earth dams shall be composed of gravelly earth with at least 15% of clay, and with no rock more than 4 in. near the upstream side, or if there be a core, next to the core on the upstream side.

The earth must be moist but not wet, well placed in layers of 12 inches slightly inclined toward the middle of the Dam. The half toward the valley or the part below the interior nucleus can be composed of material and stone less fine. The top of the Dam must be slightly convex and of a minimum width of 8 ft. and 1 ft. more in width for every 5 ft. above 15 ft in height. The inclination of the walls must be 2 horizontal for 1 vertical; if the upper part is made of the finest material obtainable, the slope may be less.

A berme or horizontal surface which will be not less than 4 ft. wide will be placed horizontally on the walls every 20 ft. below the top. On the down-stream side, these bermes should be provided with paved drains. The upstream side will be paved with rock of 18 inches from the top of the Dam to the highest berme, and farther down paved with "rip-rap". Every Earth Dam shall be provided with an overflow in masonry of sufficient capacity to allow the flow of maximum floods. This must be constructed with the same care as in the Masonry Dams. The height of the Dam will be at least 3 ft. above the water surface level, 3 ft. more if the water extends a mile, 8 ft. more for an extension of two miles; proportionally for intermediate extensions.

The Earth Dams of more than 10 ft. (3 meters) in height will be provided with a central core of masonry, the top of which will not be more than 2 ft. with an increase of 1 ft. horizontally for every 24 ft. in altitude on every side; or the core itself can be put on the upstream side

The upstream face of the dam must be built at an incline of 3 horizontal to 1 vertical. It shall be covered with a blanket over which shall be spread an abundant layer of gravel or coarse sand. If the foundation is of rock, the wood must be placed securely in the rock itself.

Earth Dams:

The upstream half of earth dams shall be composed of gravelly earth with at least 15% of clay, and with no rock more than 4 in. near the upstream side, or if there be a core, next to the core on the upstream side.

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in which case the thickness of the core must equal 1/2 of the distance between it and the top of the Dam, or else the core may be omitted altogether and the dam will then have to be 5 ft. wider and 3 ft. higher than when it is more stable in construction.

Masonry Dams:

The minimum thickness at the top of a Masonry Dam will be 1/10 of the height - not less than 4 ft. The minimum width at any depth will be 2/3 of the depth under the maximum level. The masonry will be constructed in horizontal sections with central channel at the top and on the sides made by bonding formed by placing square timbers in the cement. The concrete masonry will have vertical bars of cast iron on the upstream side placed at not morethan 2 ft. from each other in order to protect the masonry from the ice and other floating bodies.

Reinforced Buttressed Dams:

The buttresses will not be more than 20 ft. (6 meters) apart for Dams having more than 100 ft. in height (30 meters) on a foundation in the rock. The buttresses will be nearer for other Dams. They will have the necessary main Cross-beams to sustain them. The upstream side will make an angles of not more than 45 degrees with the horizontal, and the downstream side not more than 60 degrees. No part of the Dam can have a width of less than 12 in. If the Dam is on a rock foundation, the front side will have a big cut-off wall built into the rock. If the foundation is of gravel or clay between the two surfaces there must be a deep cut-off wall and a strong reinforced flooring with openings for a drain to lessen the pressure of the water under the said flooring. The drainage must be provided with interior pockets for the water that filters through. If possible, the interior should be accessible to allow inspecting. The top of the overflow and for three ft. below must be greatly increased and reinforced: the entire dam and its bulkheads will be protected from ice and floating bodies as in the Masonry Dams. The Dam must be strongly anchored to its bulkhead.

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7. Place of France and Switzerland in the Argument.

Italian Precedence.

Suitable places for secure or safe dams are not frequent.

The Removal of deceiving elements during the Inquiries.

The Statistical Report in its correlation with the vastness of orohydrography is better explained when it is spoken of as having its origin in Switzerland. There was a beginning of a propaganda started in 1912 by Eng. Killias. Not only did it have no sign of a following in any discussion that I know of in Switzerland, but neither did it have in France which has also a section of 60,000 sq. kilom. in the Alps. Switzerland and France do not know of the use of Rock Dams. For Switzerland it would be the Dam of Bischina in the Cauton of Ticino, about which the Scritti Luiggi started a false account:- but the humble little dyke is not of rock, although of the "highest type of dry masonry", has a height of 12,5 meters, and is deeper only for a few meters in the gorge, and much less deep in the remainder of the entire length of 46 meters. It has a covering of from 1 meter to .40 of a meter of hydraulic walling at the base, made of rough-cast cement. This modest little dyke did not expect to be made the standard bearer for the campaign in favor of High Rock Dams, as the pure type wanted by the Scritti L.L. Even in the Report of the original constructing Engineer Nezzola (Sept. 10, 1911) this was not suspected or hinted at.

The same telescopic growth of facts and circumstances occurs in connection with the Propaganda of the "Established Procedure in Italy" (Scritti L. L. N(4) page 17-19) in regard to the "Dry Masonry" of the Cenischio (Lake d'Alpone) and the Devore Dam. This is a good construction of the highest type of "dry masonry" containing within its limits more than would be justified by prudence. The retaining capacity will reach 20 meters (about) when important plans will be worked out to increase the efficiency of the outlest, strengthen the solidity of the Devero Dam, and raise it to a height of 30 or 31 meters, including the one point of equivocation which

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leads the uninformed reader into error,- that of counting the height of a Dam of this type from the depth of the "talion" on the wall which goes up to the plane of support of the construction.(1)(page 134)

The situation in France concerning the problem of Reservoirs gives a reason for expounding a consideration which we regard as urgent and important and which was inspired by the daily experiences of the Council.

Often the gentlemen Projectors are led by an enthusiasm due to the deceiving merits of an exhibition of comparative current plans, leading them into technical fallacies on the subject of Reservoirs; the one who writes is a warm but reasoning partisan.

Any immense cavity can become, for too many Projectors, the basis of a Reservoir, the sign of any gorge can become the starting point of a most daring Dam. Competition starts with the noting of valleys that have reservoirs and it is easy to try and rival one another for, always, on the map, the highest Dams have collected the greatest amount of water. Concerning the construction experience of my Country, which up to this time has been quite limited, there has been brought to me a most vivid impression of certain facts, very precisely exposed but very crudely too, - in a notice dated "Rome" in the "Genio Civile" of May 16, 1918. This notice was written by a colleague whom I do not know, Signor Toscani, but who is known as a constructor of note on account of the part he has taken in the construction on the Dams of Lake Delio, of Brasimone, or Corfino, of Muro Lucano, and on account of his study of the Tirso Dam. In his censure of work, there are seen fragments of truth that are still in great part not revealed in works of general technique: they have a biting conclusion to teach caution, specially in regard to the chief requisite condition of having the foundations well secured in rock. Those few pages merit the serious consideration of us all. He says openly and sincerely that the search for localities adapted for reservoirs is not an easy search and often not positively sure.

To technicians and expert geologists especilly as regards the high moral responsibility that will result to them, knowing as they do the requisites that must be exacted everwhere, America included, in regard to Dams and to the placing of Dams,- with well-measured words I want to say that the verification of the Posts or Sections must correspond to the moral responsibility, must be carried out without hesitation to a most conscientious degree, because the consequences of an error or a doubt may be incalculable in the future more or less distant but fatally certain.

Where the Water Problems of Reservoirs have already been seriously considered, the ultimate conclusions agree with those already reached.

Our Colleague, Eng. Paul Levy Salvador, Head of the French Technical Farming Water System, expert partisan of the argument, on account of his high office, writes, "Given, the Utility of the Reservoirs, it seems that they should exist in large numbers, in the high mountain valleys. The reality for many reasons is far from this specially because favorable places for the erection of big Dams in narrow gorges are most rare". (Societe d'Encouragement pour l'Industrie Nationale, Paris, 1916.)

The same conclusions have been reached after serious researches in the Eastern Alps section.

Let us move, then, in the interest of our Country, with the greatest possible activity in the search for suitable places for the erection of Reservoirs that have the means for a secure Dam. Let us try to find a way of taking away, or at least of attenuation the illusion of a great result, greater than the real result obtainable, an illusion brought about during the competition for various locations of Plants, certain ones of which are dangerous when contrasted with more serious and prudent plans. One must be very careful because very often there creep into these comparative plans elements that are misleading and that will be inevitably disastrous in the future. Such elements are deceiving and even when

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suspected, cannot always be detected.

For such reasons, it seems to me that it is the function of the State to select a Council which should give prompt and certain aid to local investigation using primarily specialists in geology who understand the necessary conditions for constructing Dams, who are made Functionaries of the State, and who have a full knowledge of their responsibility. The example of the American State Conservation Commission is worth examining. I barely outline a plan that can be followed by the proposed Commission, at the end of this Report.

8. An Overflow is fatal to Rock Dams.

Schuyler's Most Important Decree forgotten in Practice.

It's confirmation in the Lower Otay Dam.

Fortunate Escape of the Morena Dam and Escondido Dam.

Remedies for these and for the Strawberry Dam.

There does not exist a method of calculation for Rock Dams.

Important Results and Opinions of the American Discussion of 1916.

Turning to the inherent defects of a Rock Dam, I notice that the most vital problems in this Type have been touched upon in true terms by Schuyler in the original edition of "Reservoirs for Irrigation, (1897) which gave Wegmann and many othersinformation when they were recording the bibliography of Rock Dams.

Coming to a particularly grave public disaster, the break of the Walnut Rock Dam, 1890, Schuyler expounds the following conclusion:-

"The most important lesson than can be gotten from this event is that in no case is it prudent to allow the highest water level in a Rock Dam to go over the crest of the said Dam in any measure, and that it is absolutely necessary to provide ample discharges for the greatest possible exits of water without letting it get even approximately near the height of the top of the dam.(18th Annual Report of the U.S.Geological Survey, page 722).

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As I have already said and will specify again, this condition which compels one to turn to the "Maximum possible occurence" is for a quantity which it is difficult to judge of because it is always a seriously uncertain one.

To base the estimate on a maximum deducted from a brief or an insufficient period leads and has led to great errors. Cromwell, Engineer of the City of San Diego, after the destruction of the Lower Otay notes that the unit maximum of the highest water level of any previous period was surpassed seven times at the time of the disaster. In America the volumes of the Water Supply Papers give at the time every notable point of a great hydrographic plot not only the simple hydrometrical height but also a list of efficacious defluctions. Such a knowledge is lacking for 95% of our national area.

Rectifying several errors of preceding critics, Engineer Cromwell adds,-

"I know several reports made about the water system of the City by able hydraulic engineers called in for a consultation in regard to the development and the capacity of the system itself. They expressed it as their opinion that it was improbable that the Reservoir of Lower Otay would fill itself with water from its own basin to even the level of the overflow which is 11 ft. (3.35 meters) below the top of the Dam.

It seems cruel that the Omnipotent should not inform us a few weeks ahead of time when He intends to send us a deluge such as the one that raged into this basin on Jan. 27, 1916, (Eng. News April 13, 1916). In regard to the last hypothesis, I will say that the Reservoir surprised by such a downpour while still 12 ft. below the overflow level could easily have emptied, first of all".

2 The Morena Dam was miraculously saved only because the Reservoir, at the beginning of the heavy rains was in exceptionally empty condition, so much so that at the most terrible moment of the cloud-burst, at seven o'clock in the morning on Jan. 27, 1916, and after several days of violent water

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fall, the level in the Reservoir was still at 138 1/2 ft. (42.24 meters) the top of the Dam being 150 ft. so that the last terrible down-pour remained at the highest water level only 18 inches (0.4572 meters) under the crest of the Dam.

If the Reservoir had not been "exceptionally empty" even by a little bit,- the Chief Engineer of San Diego says (Eng. News Dec. 14, 1916). If the height of the water at 7 A.M. Jan. 27. 1916, had been only three feet higher, 141.5 ft. instead of 138.5 ft., it would inevitably have been completely filled and would have overflowed the top of the Dam as happened at the Lower Otay"

Here follows textually the Report:-

"It is impossible to state what the consequences would have been if a considerable quantity of water had flowed over the top of the Morena Dam, but there is one serious question involved which cannot be answered, whether the Dam could have stood under such conditions.

The Morena Dam is a type of Rock Construction not built to withstand the overtopping as would an overflow type of dam.

It might have resisted such a condition, but we have not the right to say it would have, which, according to me, would not be a wise statement".

All the others (and I cite the Eng. Record of June 10, 1916, on account of its excellent note) and the distinguished California Engineer George Binckley of Los Angeles have concluded that the Morena Dam was "marvelously saved", or had a narrow escape. They all recommended a great reform in efficient overflow discharges.

In regard to the Morena Dam, in the Report of the "Documents of the A.S.C.E. 1912, the Constructor O'Shaughnessy did not give any special indications; requested to make it clear, he adds to the discussion that the highest water-level measured on the same Cottonwood Creek below the Morena Dam at Barret, where the basin is 250 sq. mi. (647.5 sq. k.) had had about 7000 cu. ft. (about 198 cu. m.) so that at the location of the Morena Dam

fail, the level in the Reservoir was still at 139 1/2 ft. (42.54 metres)
top of the Dam being 150 ft. so that the last terrible down-pour reached
at the highest water level only 10 inches (0.4572 metres) under the crest
of the Dam.

If the Reservoir had not been "exceptionally empty" even by a little
bit,- the Chief Engineer of San Diego says (Eng. News Dec. 14, 1916), the
the height of the water at 7 A.M. Dec. 27. 1916, had been only three feet
higher, 161.5 ft. Instead of 139.5 ft., it would inevitably have been
completely filled and would have overflowed the top of the Dam as happened
at the Lower Otay"

Here follows textually the Report:-

"It is impossible to state what the consequences would have been if a
considerable quantity of water had flowed over the top of the Morena Dam,
but there is one serious question involved which cannot be answered,
whether the Dam could have stood under such conditions.

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7000 cu. ft. (about 198 cu. m.) so that at the Junction of the Morena Dam

with a Reservoir having a capacity of 15 billions of gallons (57 million cu. m.) and with a basin of only 135 sq. miles, the Author had full confidence in the sufficiency of the water flow. (loc. cit. page 64).

Facing the fact that a water-level of more than the supposed maximum, and after the extraordinary escape of the enormous Reservoir whose ruin would have produced a terrible disaster, it is only natural that a sudden increase for the water flow has been added to all the most recent dams. (Eng. News, Dec. 14, 1916.

It is also a significant fact that for the Strawberry Dam (while the particulars are lacking in the Report of Constructing Engineer Howson, Eng. News, March 30, 1916, edited probably before the Lower Otay Disaster) in the already mentioned description of the Eng. Record of Aug. 26, 1916, there is given a new way to measure the flow capacity by flash boards, and it mentions that the flow capacity will be four times that of the greatest defluxion recorded on the basis dominated by the Dam,- significant prudence which one might say is excessive, and which is materially impossible in our Country.

Concerning the Strawberry Dam which was not far advanced in construction in the summer of 1916, there is not another single later notice.

At the same time, in attempting to remedy the few Rock Dams, notably in the Western America, the truth is that they had to turn to the dictates of Schuyler. This action finds its definite sanction in the Discussion of the event of Jan. 27, 1916, concerning the Lower Otay Dam, the sources of which have already been specified in paragraph 3 and to which we refer as to the vest part of the meager bibliography on Rock Dams.

A few inexact facts are corrected in the course of the Discussion. A few favorable, brief signs are drawn up in the Eng. News which have already

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been combated recently and overcome in the same Eng. News and in the Eng. News Record by other circumstances than those of the disaster so minutely written up in the Eng. Record of Feb. 12, 1916 by Engineers whose worth is already known,- nearly all Californiana. These men bring to the periodicals the technical theories of the U. S., the echo of thoughtsand of numerous local articles that we would not notice. The Eng. News of Feb. 10, and of March 9, 1916, tend rather to exonerate this type of construction, and to put the blame on the material used in the walls of the Dam.

Let us turn to Ralph Bennet of Los Angeles, California.(Eng. News, March 9.)

"It seems that you want to suppose that the down stream side of a Rock Dam if covered with blocks of stone can stand the overflow from the defluxion. I do not believe it a correct theory, or a practice suitable to this Rock type to allow a discharge on the back of such a structure."

Follows an acute analysis to which as always I refer, confirming among other things, that the calculations of the stability of Rock Dams are of very little significance.

The suggestions of Sellew and others to exact besides an absolute condition of no overflow, other coefficients of security,- 3.5 or better, 4 against a slipping of the base -- are useful suggestions. Other well-known California Engineers such as Jorgensen (written on Discussions and Reports on Arched Dams) Bennett, Binckley, affirm with sincerity that there is no way of calculating for such a structure. #1

Bennett shows, among other things, how the penetration on the water into the body of a Rock Dam due to overflow gives rise to new conditions resulting from loosening, sinking and displacement. Schuyler's prejudice against Rock Fill Dams becomes justified.

More forceful still is the note to which Horace King, the illustrious Engineer and Professor in Michigan University refers. Referring to the brief notice in Eng. News of Feb. 10, 1916, he says:

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More forceful still is the note to which Morse King, the illustrious Engineer and Professor in Michigan University refers. Referring to the brief notice in Eng. News of Feb. 10, 1916, he says:

"Rock Dams are adaptable to certain localities in the western part of the U. S. and for rivers flowing through rock canons where the material for an Earth Dam is scarce, and the cost of constructing a Masonry Dam is prohibitive".

Then follow notices of the applicability to "certain parts of the Western U. S." which accentuate still more efficaciously what has been noted concerning the conditions of a vast region almost deserted and of great hydraulic power,- conditions very different from those of the Eastern U. S. and very different indeed from those of Italy.

The Chief Engineer of the City of San Diego, Cromwell, who writes in the Eng. News of Apr. 13, 1916, rectifies in his report several important former errors, in his letter of March 23rd.:

"Of all the discussions concerning this break,- the Articles of Jorgensen and of Horace King are the most important, and it is these that approach the truth more than any article I have seen".

Cromwell concludes:

"The break was due to the overflow because the flow capacity was insufficient for such a high water-level, higher than any preceding. However, I do not think that any Engineer in the whole country would have recommended a larger flow capacity judging from the measure registered of previous rainfalls before the recent violent storm."

Another precious Note that contains acute observations and to which I refer, is given by the California Engineer E. Trask in the Eng. News of May 25, 1916. The note reveals the condition by which another Rock Dam was barely saved,- the Escondido Dam also in Southern California. It was planned by Trask. The Notes throw light on some truths that are not even mentioned in the Scritti Luiggi, and in those of his followers. We touch some points of great importance in respect to the criticism and construction, avoiding thus the least doubt in regard to the technical side, interesting in itself, but here secondary:-

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but here secondary.-

"The 7th of July, 1890, the writer being a Consulting Engineer in the District of Escondido Irrigation System, stated that he counseled the building of a Rock Dam in the place where it was later built. During the recent torrent of Jan. 1916 this Dam had an overflow of two inches (5 centimeters) at the two ends, and of more in the center where for a distance of 60 ft. (18 meter s) the excess was 12 inches (30 cm.). The rock fill lowered in some places 1 ft. and a small quantity was displaced on the down-stream side. That this structure is still standing is due only to the fact that the body of the dam was composed of strong blocks with large spaces free from sand, earth, clay etc.

"It is well to remember that the disintegration of the mass of the rock-fill in this type of dam is always taking place with the result that the settling and adjustment of the whole mass and of the interior mass, produce a tendency in the whole structure to slip toward the down-stream when it is subjected to the increasing pressure produced by the rapidly rising water in the Reservoir. Above all, I maintain that Rock Fill Dams never should be used where there is an overflow. The writer wishes to call attention of engineers to the great breaks in the mountain canons of Western America. These immense hog-back Dams of rock broken in past geological days, have slid into the canons of the adjoining mountains and have completely barred the canon and have created lakes or reservoirs, in some cases, thousands of feet deep. In all cases known to the writer, these natural rock-fill dams have been broken by the overflow of water, and have been broken like real dams notwithstanding the fact that the cross-section is much stronger than that of any artificial construcion ever made. The lessons of the sliding in the two Rock Fill Dams of California,- the Escondido and the Lower Otay, are of great value and can be resumed briefly thus:

Rock-dams should not ever be constructed unless they are safe-guarded by a generous use of spillway that assures the structure against overflow.

In these Dams only rocks of crystal formation, hard and durable, and in large blocks free of fine material, should be used. These Dams should be designed with a coefficient against the slipping of not less than 3.5 with a protecting wall."

There follows in the same paper a notice of a new type of Gravity Masonry Dam proposed for the San Diego Otay Valley by the sane O'Shaughnessy (Eng. News, Aug. 3, 1916) who on account of the varied ups and downs of the Morena Dam, augments greatly the number of outlets. (Eng. News Dec. 14, 1916).

More brief but important, and equally deadly in it conclusions, is the review in the Eng. Rec. of Feb. 12, 1916 which starts a complete minute description, and which has the remarkable description of the California Engineer George Binckley (to whose writings I refer you, not having had the time to translate the entire discussion as it should be translated) where it is decided again that the overflow is the only real cause of the break in the Lower Otay, and where are given acute, original conceptions about the character of the structure made of an amassing of stone, and about the ruinous effect of the penetration of the overflow water in the Body of the Rock Dam.

9. Secondary Arguments relative to the Propaganda.

The disintegration of the Materials.

The Over-pressure.

The Foundations.

Heat Variations.

The decisive facts exposed by the planner of the Escondido Dam, Trask, show that overflow means disintegration and settling in the interior of the dam even when constructed with large blocks of exceptionally hard rock, as in the Escondido Dam. With great reason we can infer that in time the rock will become less solid as the "mica-Shist" so common in our Alps.

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decay of such structures that are of a monolithic type, but they do not mention that the type they advocate on which the many factors of disintegration are operating, become disintegrated much more quickly.

The disintegration in the case of rock not exceptionally hard must destroy with time the lower layers of the Dam, if they are not more compact than those whose porosity allows free infiltration of the water.

This theme is connected with that of the under support which is erroneously considered as not existing in the Rock-Fill type: it is connected with that of the foundations considered with inexcusable indulgence in the Scritti (N 4 page 25) while in every example of the High American Dams is placed the condition of joining with a protecting wall the firm rock under the whole circumference. But the development of these conceptions that are found in the arguments, much debated and difficult, of the under support and of the penetration of water into the body of the Dam through the natural surface at the foundation, might take us too far away from the immediate object of this Note. They can be explored elsewhere, for instance in an immediate argument by the Commission appointed to study concerning Dams in general. Here, it would be a development out of place and disproportionate to the scheme of the assertion made by the Scritti Luiggi.

The Thermic argument about cement dams, the last topic in the Scritti L.L., is another propaganda in favor of Rock Dams. While at first it does not appear so, it is not at all comprehensible:

"On the Italian Dams barring the valleys turned toward the North the sun does not beat directly on the side facing down stream, and that facing up stream for the greater part of the year is immersed in the waters of the Lake and does not feel greatly the variations of temperature. The result is that the phenomenon of the contraction and dilation of the wall cut off at Assuan passes almost unnoticed in the Italian Wall Dams. (Scritti L.L. N (3) page 20 of the Estratto).

many of such structures that are of a monolithic type, but they do not mention that the type they advocate on which the many factors of disintegration are operating, become disintegrated much more quickly.

The disintegration in the case of rock not exceptionally hard must destroy with time the lower layers of the dam, if they are not more compact than those whose porosity allows free infiltration of the water.

This theme is connected with that of the water support which is erroneously considered as not existing in the Rock-Fill type: it is connected with that of the formations considered with impermeable backing in the Soritti (N 4 page 85) while in every example of the High Masonry Dams is placed the condition of pointing with a protecting wall the rock under the whole circumference. But the development of these concepts that are found in the arguments, much debated and difficult, of the water support and of the penetration of water into the body of the Dam through the natural surface at the foundation, might take us too far away from the immediate object of this Note. They can be explored elsewhere, for instance in an immediate argument by the Commission appointed to study concerning Dams in general. Here, it would be a development out of place and disproportionate to the scheme of the assertion made by the Soritti Luigi.

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Instead the thermic report is repressed. It would not be out of place to glance at the geographic and climatic condition of the place where at great heights with an extememly small climatic extreme, and where springs are unknown, they build and will continue to build in our valleys grand and magnificent Gravity Dams of cement or Arched Dams without there ever being a trace of a Rock Dam. It will be enough to refer to the report of the U. S. Weather Bureau for precise information on climatic conditions. The report of 1908 by Bigelow on the climate of the U. S. with an annexed chart is very comprehensive.

10. Report on the Security of Rock Fill Dams and the Provision of a Spillway Capacity.

The Character of absolutely the Greatest Occurence.

Main Difference between Our Rainfall and That of Western America.

Conditions of the Problems in the Alps and the Apennines.

Turning to the fundamental point, we must consider the overflow as the great destructive force in Rock Dams as shown in the settling and the displacements that are due to breaks in the thin mantle that covers the walls, the intervention of destructive factors already mentioned, water, and the height and velocity of the escaping jets of water.

This being settled, I remember the examination of the recent "Instruttari whose allusions already have revealed to me how the idea of covering the external walls with blocks to prevent dangers by overflow, was regarded officially. Such a presumption cannot endure after being well explained and after the advertisement made of it in complete description.

The first condition for the existence of a Rock-Fill Dam depends on the flow capacity. But this decisive matter is considered with inconsequented ease while any other matter (theme) would be considered after firm reflection.

A dam that lasts four, five, ten years is a Dam that "functions well". Such judgment has no sense in it. It is not deduced from a specific

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examination of the construction but made simply because the structure had stood four, five, ten years.

Above all, the water manifestations that in a long, a very long time,, can produce the gravest disaster, are looked at very differently from those that have already been seen and commented upon. An occurrence that may be fatal is looked at as far, very far away. In fact in every place where one has not spcific data to depend upon, one trusts to intuition concerning the construction. But there are other causes that bring about the deterioration of the construction. I speak of the under-support, the slow penetration of the water by pressure, a cause potentially active from the beginning but which works continuously year after year, and which finishes only when the structure is destroyed.

Now we come inevitably to the "greatest extraordinary event", and I confess that first motive of the "Scritto" of mine concerning the essential nature of Rock-Fill Dams is (L.H.P. to express) my mature thought and experience on that which to us signifies the most terrible accident, the maximum discharge of the water from a basin of given size in a given region

But then it could be easily claimed that, being in accord on the subject of overflow in a Rock Fill Dam is equal to its destruction, it will suffice to make the flow capacity ample enough to guarantee it from the unexpected by large margins of safety, say by two to four times the greatest noted water-level, as has been done in the cases of Otay, Morena and Strawberry Dams in California as the result of experience had in Rock Dams.

Instead this point is another theme upon which current thought finds an insufficient knowledge of facts.

If one considers value and the distribution of rain-fall in North America, e.g. on the chart of Henry in the U. S. Weather Bureau for the period 1870-1901, or in the more recent one by Gaunet, U.S. Weather Bureau (W.S. Paper 234) or better still, in the already mentioned work of Bigelow (U.S. Weather Bureau) it is shown that in El Dorado, with few noted Rock Dams

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(situated partly in South and partly in Central California) the greatest part of the area has an annual rain-fall of from 0 to 10 inches (0 to 25 centimeters). At an altitude of about 1000 meters in the Morena Reservoirs, a report of O'Shaughnessy (Documents of the A.S.C.E. Aug. 1912) gives for five years an annual rainfall of from a minimum of 13 inches (33 centimeters) to a maximum of 35 inches (89 cm). Thus in the immense region of the Far West, the greatest part has an annual rainfall of from 0 to 10 in,, a small part 10 to 20 in., and a very small part, a little more.

Without referring now to 2 1/2 and 3 1/2 meters in some notable sections of the Alps and Apennines we will consider only the meter, and a half or less, in the interior sections of the Alps and Apennines, it is easy to see that if in America a secure excess of from 2 to 4 times the possible maximum of the water-level is sufficient, it is difficult to estimate practically, and almost impossible to provide, such protection in our countries.

The maximum possible discharge in reference to a square kilometer of a basin of area A in square kilom. is a problem not only in regard to all the climatic and plastic elements of the basin, but also of the size of A specially as the boundaries of A are of interest as applied to Reservoirs.#(1)

All this is general, as there is not present data applicable- research exacts special study for every case. There is nothing certain for all cases. Thus until a few years ago, I thought that a discharge of 9 or 10 cubic meters to the square kilometer was possible only in certain section of the Ligurian Apennines having basins of only a few square kilometers.

The study for the city of Genoa of an extraordinary cloud-burst that devastaed the estern Riviera at the end of 1915, showed me that a discharge of 10 to 12 cu. meters per second to the sq. kilom. is possible. The number deducted by careful investigation and from direct study was very little talked about, while a distinguished Ministerial Commission, basing its estimates on the data of rainfall and on conventional, but fallacious hypotheses on the distribution reached numbers that were three times

greater than mine.

In one of our Central Alpine basins of 6,000 sq. kilom. it was materially possible in a memorable event, to have a discharge of 2 cu. meters per second to the sq. kilom. as the average in the basin. In another high water-level, it was possible to have a discharge of 3 cu. meters per sq. kilom. in a basin of about 1600 sq. kilom. (Bacino Dell 'Ossola of the Val Toce). These figures show, as possible, a discharge of at least 5 or 6 cu. meters per sq. km. in a small basin of 10 sq. k. even out of the zone most exposed to heavy rainfalls.

In fact, two erudite colleagues, interested or present in two different places of the said Ossolance Valley, assured me that, in the cloud-burst that struck the Alpine Valley of the Ossola last month, June 1918, with violent S.E. winds, the diacharge had a force of 200 cu. meters in an Alpine basin of 80 sq. km. (Alta Ovesca) i.ee 2 1/2 cu. meters per sq. km., and a discharge of 5 or 6 cu. m. for every sq. km. of the basin of only a few sq. km. of Lake Vaunnio in an absolutely Alpine section at an altitude of over 2,200 meters; numbers which the undersigned already presumed to criticize personally on account of the highest level of the Toce more directly affected by the S.E. winds. All this leads to an argument hardly great enough to merit, for any length of time, the attention of all the volunteer observers that conclude, being intimately acquainted with the facts, and by reason of the bond existing between the rising of the water and Rock Dams, that a certainty or at least a probability of a disaster exists.

This must strengthen the remembrance of how the same argument of an absolute maximum level is treated in the "Instruttarie" in an entirely inadequate manner, almost as plans for ordinary times are treated.

My impressions are not like those of the Promoters, but I must bow to a most honorable opposition of the Ministerial Commission. This Commission in regard to the Southern slopw of the Alps, Rosa Group, in regard to little basins 10 to 14 sq. km. for use in plans for Rock Dams was "of the opinion

greater than mine.

In one of our General Alpine basins of 6,000 sq. kilom. it was materially possible in a memorable event, to have a discharge of 2 cu. metres per second to the sq. kilom. as the average in the basin. In another high water-level it was possible to have a discharge of 3 cu. metres per sq. kilom. in a basin of about 1800 sq. kilom. (Basins Dell 'Ossola at the Val Toce). These figures show, as possible, a discharge of at least 5 or 6 cu. metres per sq. km. in a small basin of 10 sq. K. even out of the zone most exposed to heavy rainfalls.

In fact, two erratic collapses, increased or present in two different places of the said Ossolanca Valley, assured me that, in the storm-burst struck the Alpine Valley of the Ossola last month, June 1915, with violent S.E. winds, the discharge had a force of 500 cu. metres in an Alpine basin of 80 sq. km. (Alta Ossola) i.e. 2 1/2 cu. metres per sq. km., and a discharge of 5 or 6 cu. m. for every sq. km. of the basin of only a few sq. km. of lake Vannio in an absolutely Alpine section at an altitude of over 2,800 metres; numbers which the undersigned already presumed to criticise personally on account of the highest level of the Toce more directly affected by the S.E. winds. All this leads to an argument hardly great enough to merit, for any length of time, the attention of all the volunteer observers that concludes, being intimately acquainted with the facts, and by reason of the bond existing between the rising of the water and flood dams, that a certainty or at least a probability of a disaster exists.

This must strengthen the remembrance of how the same argument of an absolute maximum level is treated in the "Instructerio" in an entirely inadequate manner, almost as plans for ordinary times are treated.

My impressions are not like those of the Promoters, but I must bow to a most honorable opposition of the Ministerial dominazion. This Commission in regard to the Southern slope of the Alps, Rose Brown, in regard to little basins 10 to 15 sq. km. for use in plans for Hoch Dams was "of the opinion

that a flow capacity of 1 cu. m. per sq. km. can be adopted in calculating th quantity of water when full to overflowing".

The greatest security against any specil emergency is a doubling of the outlet. But it is certain "that the greatest possible maximum can be retained by having an outlet at least four or five times "that of 1 cu. meter" which the Honorable Commission considers sufficient.

The "limit of the possible" conceived in this case is not considered in regard to climatic conditions more or less ordinary but in conjunction with the "entire regional absolute possibility", that is, in a long period during which there is no extraordinary happening, such as cloud-bursts from the S. E. winds, in that particular valley, particular direction, or particular little basin.

Therefore these intense discharges of at least 4 or 5 cu. m. per second per sq. km. in the small basins are a measurement already confirmed by occurrences in the Central Alps region which I am considering at this time. No one can tell what the "maximum absolute" will be in the immense cycle of all sorts of combinations and of weather interferences, be it in 1 year, 10 years or 50 years. All I can do is to repeat much of the material and of the precious contributions offered by those who observe carefully -- the engineers, local agents of the Plants, etc.

For 19 years that the Lower Otay existed, the precise statistics of San Diego had well established the unit of maximum water-level, and the level had never been surpassed in the Reservoir, until there came an event which raised the level-unit seven times more that the maximum of the 19 years preceding.

ERROR, the fatal crime, is not the fact itself. It lies in the person who considers that such an extraordinary event can be confined in the experimental basin of 19 years; it is sufficient to consider what such an occurrence as the great meteroic event means in a historic way, e.g. Take Lake Maggiore which, in 1868, reached a higher water-level, - twice

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course of all sorts of combinations and of weather interferences, be it in
year, 10 years or 80 years. All I can do is to repeat much of the mater
and of the precious contributions offered by those who observe carefully
the engineers, local agents of the Plains, etc.

For 12 years that the Lower Otay existed, the precise statistics of
San Diego had well established the unit of maximum water-level, and the
level had never been surpassed in the Reservoir, until there came an even
which raised the level-unit seven times more than the maximum of the 12
years preceding.

ERROR, the fatal crime, is not the fact itself. It lies in the
person who considers that such an extraordinary event can be confined in
the experimental basin of 12 years; it is sufficient to consider what suc
an occurrence as the great meteoric event means in a historic way, e.g.
Lake Lucerne Region which, in 1834, reached a higher water-level, - twice

as high as had been knownthere in the 100 years preceding.

11. Conclusive Allusions to Rock Dams.

A Proposition to Revise the Outlets.

A Proposition for the Study of the General Problems of Dams, and of the inherent Rules.

Now, in all these water problems, one can fortunately single out the maximum absolute from the relative maximum; thus one can admit the fact that a net-work of the sewerage overflows into the street three or four times in 30 years. It can be admitted that the Reservoir of a City Aqueduct does not correspond to its contents two or three times in 20 years; that the canalization works in a City,on account of torrents and under great pressure, rejects its water once in 50 years etc.

Instead in the special case of Rock Dams, on account of the cruel correlation between the two terms,- overflow and ruin,- the absolute maximum is a condition that cannot be overlooked, because a Dam that can last only 30 years will not be acceptable to anyone. On account of the technical uncertainty of such an estimate, even when estimated with greatest knowledge and care, I am opposed to the application of such structures in Italy.

This structure, which is in great minority or hardly used in the Far West, which is relatively deserted and where its life seems almost expended,- cannot dominate our populous valleys, with no plastic comparisons in the climatology, as I think I have shown with sufficient notice.

I, who deprecate the use of Rock Dams at the bottom of a given precipitous opening more or less thickly populated like our valleys, would admit their use if situated at 50 km. further in where it would cross a deserted valley, and where the terrible force of the water during a break could be fairly well attenuated. (Page 135) (2)

But the application of these remedies and of these margins of security for the flow-capacity 3 or 4 times the known maximum, that can be used in

as high as had been known there in the 100 years preceding.

II. Concluding Allusions to Hook Dams.

A Proposition to Revise the Outlets.

A Proposition for the Study of the General Problems of Dams, and of the Inherent Rules.

Now, in all these water problems, one can fortunately single out the maximum cosolute from the relative maximum; thus one can admit the fact t a net-work of the sewerage overflows into the street three or four times i 30 years. It can be admitted that the reservoir of a City Aqueduct does n correspond to its contents two or three times in 30 years; that the canali tion works in a City,on account of torrents and under great pressure, replete its water once in 30 years etc.

Instead in the special case of Hook Dams, on account of the cruel correlation between the two terms,- overflow and ruin,- the absolute maxim is a condition that cannot be overlooked, because a Dam that can last only years will not be acceptable to anyone. On account of the technical uncer ty of such an estimate, even when estimated with greatest knowledge and car I am opposed to the application of such structures in Italy.

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I, who deprecate the use of Hook Dams at the bottom of a given precipi tous opening more or less thickly populated like our valleys, would admit their use if situated at 30 km. further in where it would cross a deserted valley, and where the terrible force of the water during a break could be fairly well attenuated. (Page 150) (2)

But the application of these remedies and of those searching of security for the flow-capacity,2 or 3 times the known maximum, that can be used in

California, cannot be used in our courty where the rainfall is generally five or ten times greater, and where the unit of the water-level is notably and exceptionally high for our small Apennine and Alps basins.

This reason is sufficient in itself for my decided aversion to Rock Dams, especially as propounded in the Scritti Luiggi, but it is not the only one. Among others shown in the present report, is a lack of faith in the durability of the cement layer spread on the upstream side of a Rock Dam in the case of a break or fracture due to the interior displacement of the rock mass caused by an overflow.

The greatest danger for this cement covering in artificial lakes subjecte to long periods of low temperature, resides, in my opinion, in the localization of the great horizontal strain which occurs at certain times, and, in the more rigorous winters, by the existence of a powerful pressure due to ice in the Reservoir.

The action is localized along an undetermined strip of the thin cement-covering, and cannot help but become dangerous, eventually beginning a fracture which will end in a terrible disaster.

These actions which have a special effect on all Rock Dams also have an important effect on all Dams in Alpine lakes. This "ice-pressure" is considered very dangerous, and the State of New York, where there are no high altitudes but where the temperature is low, has made very severe laws to meet this danger. The temperature there is as low as that of most of our Alpine sections,- 20 to-40 degrees Fahs. (-20 to-40 degrees Cent). It is quite different in California. Central and Lower California have an absolute minimum of 10 to 30 degrees Fahr. (-12 to 1 Cent.)

This thermic study, which I hardly stop at here, shows many things, among them that the Morena and Escondido Dams, as well as similar ones in S. California, cannot be compared with those of our Alps nor yet with some of the Apennines.

We need a greater information in regard to these arguments. Already

they say in the most important recent number of the "Instruttoria", in regard to Rock Dams, that the water collected in the frozen Alpine lakes "cannot evidently increase the hydrostatic pressure of the stored water.

I think I have justified the point mentioned in paragraph 2 about the merits of a technical propaganda animated no doubt by good faith, but according to my view, most perilous in its tangible effect in the future, on account of the high position held by my most honorable and zealous opponent.

I dedicate these Notes to the Coundil invested with such a great responsibility, but at the same time I destine them also to the technical public, because I deem it necessary and urgent to prodeed in this way.

These Notes have not only a negative conclusion most disagreeable to the great amount of capital invested at present; but they also have several positive conclusions that appear in the reading, and through attentive comparison.

They have two important immediate possibilitiss which certainly have already been sufficiemtly illustrated in all that precedes: to these correspond my two following propositions:

1st. The demand of a revision of all the outlets in Rock Dams,- a demand to be prepared specially by the Council by whom permission to construct has already been given. There is no difficulty, according to my opinion, that should prevent the correcting of a defect which will insidiously cause a grave disaster in time.

2nd. The demand for a special Commission to examine the subject of High Dams in relation to work to be done by the State. A small Commission composed of some of our own scientists, of othersfrom the Superior Council of the L.L.P.P., and from the Royal Geological Office, and also a few foreign technologists to the said Council, who will have specil scientific knowledge on the problem of constructing Dams.

The final aim must be to find standard laws for the plans and constructio of such works. May special important investigations can be carried on, which I cannot specify here because of the lack of space in the Notes, but which are indicated.

In such technical constructive investigations, the water criterion

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In such technical constructive investigations, the water criterion

gives decisive warning against purely statistical construction such correlations between pure statistics and the material that must be reckoned with, are sometimes very poorly defined even in the most thorough collections of Statistical calculations for the structures.

There is a demand for standardization. I make mine the vote of the brilliant Professor Camillo Guidi in regard to the general study of special specific Italian conditions. (See the letter in the Giornale del Genio Civile of March 1918 which refers to the number of Feb. 1918.)

I accept it but with a rectification in the motive it gives. In another interesting debate with Guidi, another of our Colleagues, the Eng. Forti, had shown that all the disasters recorded by Guidi in American were due "to the freedom and the lightness of construction that know no limits". Guidi objected, fearing the dangerous results that would come through the importation by the great Alleato of the "undertakings of audacious enterprise These fears are unjustified and are excluded because of the reults of today. The U. S. of America is not what it is so often represented to us, so inexactly and so falsely, specially in regard to the inherent problem of Dam construction.

Laws prescribed by the State of New York, and all other indications mentioned in Paragraph 6 of these Notes concerning Legislation in the U. S., indicate that the State Officials in the U. S. treat this subject with the greatest amount of severity and regard it as a very important Government Problem. This just severity does not forbid high and daring constructions but does not admit of light constructions which would endanger the lives of its citizens.

Therefore in this modern specific theme, of immense public and private concern, the same noble U. S. of America can certainly offer us, with its great field for experimentation and research, much wise teaching, and be a judicious, cautions guide.

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Milano, July 25, 1918.

Read before the Comitate Permanente del Consiglio Superior della Aegue, August 1, 1918.

Ing. Gandenzio Fantoli.

Milano, July 25, 1918.

Read before the Comitato Permanente del Consiglio

Superior delle Acque, August 1, 1918.

Ing. Gaudenzio Fantoli.

FOOT NOTES

Page No. 21 line 1 (Orig. p.19) See the Cornell Civil Engineer of Feb. 1917. A remarkable monthly periodical published by the Assoc. Civil Eng. of Cornell University.

Page No. 21 line 20 Orig. p.19) Notwithstanding this for many years he has gotten personally the most important American publications, and had gotten the Milan Technical Library to get the chief periodicals, Eng. Recore, Eng. News, Proceedings of A.S.C.E., Professional Memoirs of the U.S. Army, The Cornell Civil Engineer, and several others. These are enough because all the technical matter is passed in review.

Page No. 63 line 3 (Orig. p.54) Note During the Printing.

During the printing of this Scritto in Milan, Italy and during its rading in Rome Aug. 1st I have purposely admitted superficial and different readings of accessory expressions, leavi the text unaltered as it came from a rapid editing. Before sending it to print, however, the context was conscientiously studied over. If the form and lines are in part so different from what I should desire, the sincerity necessary for the great work I have undertaken is not lacking. I exclude also colleagues through whom would have been given interesting confirmation of proofs and of notes to divers paragraphs of this Scritto. I can state that I could now get confirmation and important notes from the "Documents of the Congress of International Engineers" held at S. F. Calif. from Sept. 20 to 25, 1915. These Documents which were printed in 1916 and which I have only been able to examine this month contain another immense synthetic report on Dams by A. P. Davis, Chief Eng. of the Reclamation Service and by Dr. Henny. I could take from the same Documents interesting and singular

POST NOTES

Page No. 21
line 1
(Orig. p.19)

Page No. 21
line 20
Orig. p.19)

Page No. 63
line 3
(Orig. p.84)

observations concerning the use of the hydrographic and agrarian materials in Italy, and also concerning the use of Rock Dams already in great favor in Italy and in Libia in Sept. 1915,

Page No. 79 line 27 (Orig. p. 69) On the flow due to breaks in large Reservoirs.

Not on account of vain fear, but to stimulate a search for greater security and caution, because it is well-known what a disaster to one of the great constructions of today would signify, it is well to remember that with the breaking of a High Dam of a Reservoir of great capacity, there rushes into the valley below, a flow that, for some ten thousand cu. meters to a second, lasts several hours if there is a great quantity of water gathered. The principal factors in computing the discharge in the section of a Dam that is supposed to be destroyed are the height of the Dam, the size of the section facing the gorge that it bars, the capacity of the Reservoir or rather of the shuetto (gate) behind it. The first two factors determine essentially the force of the flow: it is quickly seen how the break in a dam 50 meters high with a facing on the gorge of only 2000 m. will act, if the Dam breaks quickly, or jumps like a being, or opens like the halves of a double door. (Lower Otay). The effect of the initial flow of 10,000 cu. met. to a second is apparent. The third factor determines essentially the length and form of the immense flood of the discharge due to the emptying of the Reservoir. They are making what may seem an exaggerated but most interesting investigation on the exact importance of the sections to a valley, in computing approximately the flood of the discharge f (Q.T.) when "Q" is the discharge per second, the time "t" of the initial break in the broken sections and also in the sectio

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of the walls facing the valley, which were greatly expanded. They are considering a Masonry Dam of 30 meters in height with a reservoir of five or six million cu. meters. The computation is not easy, even with exact calculations as to the maximum velocity of the water flow. The Lower Otay Reservoir with a capacity of 49 millions cu. meters, with a mediocre retaining wall about 40 meters high, and with a narrow canon gorge barred by it, emptied its contents in about 2 1/2 hours after the initial crash. The average of the discharge was 5,500 cu. meters to the minute. In the first hour and a half, the average unit of the discharge was 8000 cu. m. to the second, twice as muct as in the Tevera Dam when it reaches a maximum water-level.

But these forces are sufficiently overcome by walls really high and by reservoirs of sufficient capacity. If mentally I deplore the hypothesis of our Italian conditions, it is because I know that in general, there is only a confused and inadequate idea even about the immense floods due to defluxion and to its presumed destructive effect on the surrounding country. If I do not hesitate to state that a disaster, in certain places where great Reservoirs exist, might be more than a local one, it is because I believe in exercising every precaution, in calculations, in construction, in effective quantities of safety that cannot be overestimated especially in the most dangerous locations.

If I refer to the recent wise decision already stated, of the officials of the State of California, which State is still far from having the dense population and the intense improvements of our old soil wherein every place man has already built up his own fields, as says Cattaneo; and if we refer to the

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example of organization of the N. Y. State Conservation Commission, it is because I am convinced that without analogous preceedings, there never will be found a solution to the problem.

Page No. 3 line 19 (Orig.p.5)

I will indicate for the sake of brevity the sources of information:

G.G.C.- Giornale del Genio Civile (Journal of Civil Engineerin

A.I.I.- Annali della Societa Ingegneri Architetti Italiani. (Annals of the Society of Italian Architechtural Engineers).

E.R. and E.N.- the two most important technical journals of engineering,- the Record, and the Engineering News. These appear in large weekly numbers which were fused on April 1, 1917 into the precious:

E.N.R.- Engineering News Record.

P.C.E.- the very important Proceedings of the A.S.C.E. which appears monthly with the discussions of the T.C.E. Transactions of the A.S.C.E.

Page No. 5 line 19 (Orig.p.7)

See the note of the distinguished Camillo Guidi, particularly the one in the G.G.C. Feb. 28, 1918 that has just appeared, and in which there is this brief paragraph that has a great bearing on the subject in hand. "And now, for some technical considerations. Dams are divided distinctly into Earth Dams, Rock Fill Dams, Resistant Masonry Dams-- like those of retaining walls -- and Reinforced Concrete Dams.

Those of Masonry are, according to Forti, the classic dams. Those of specially resistant quality give the greatest guarantee for success. On this we agree with him, but they are now constructing them of earth and rock, The Supreme Council of Public Works, it appears, on the 30th of Dec. 1916,

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Those of Masonry are, according to Peril, the classic dams. Those of specially resistant quality give the greatest guarantee for success. On this we agree with him, but they are now constructing them of earth and rock. The Supreme Council of Public Works, it appears, on the 30th of Dec. 191[illegible] declared the official acceptance of [illegible]

stated that it was right to construct the Dams as high as possible and counselled them as preferable in the high mountains.

But moreover, can we even declare ourselves satisfied with our technical knowledge even in regard to Masonry Dams ?

Page No. 10 line 17 Orig. p. 11 U. S. Geological Survey. Water Supply Paper, N. 395 "Colorado River and Its Utilizatio Washington 1916, pages 12 and 22.

The basin of the Colorado is 244,000 sq. miles. So as t be able to keep the table measures the same as those used in the U.S., I will give the following table for converting them (Smithsonian Physical Tables, 1910 from page 7 on).

Pollice	in.	M.	0.0254
Piedi	ft.	M.	0.3048
Yard	yd.	M.	0.9144
Miglio	mile	Km.	1.6093
Miglio Quadrato	sq. mile	Sq.Km.	2.5900
Piede Cubico	cu. ft.	M.C.	0.0283
Yard Cubico	cu. yd.	M.C.	0.7650
Gallone U.S.	gall.	Litres	3.7854

Page No. 11 line 30 (Orig. p.12) For an approximate idea of such conditions, see the usual good supports used in orohydrographic and hypsometric construc tions, for example, those of Bartholomew, London, 1914, and th demographic statistics reported also in the "Annaire au Bureau des Longitudes", 1915 and preceding.

Page No. 13 line 10 (Orig. p.13) The actual date because the number appeared later, so that the Note on page 4 calls for Scritto N (5) on the Strawberry Dam, which appeared in the number of Mar. 16, 1917, A.I.I. an interesting circumstance for us.

Page 25 line 1 (Orig.p. 22) — Arched gravity Dam, cyclopean concrete, plums 25% to 30% Total volume. See Kensico Dam, Eng. News, April 25, 1912.

Page 28 line 7 (Orig. p. 25) — See Memoirs of Commissioner of Science and Letters, of Lombardy, 1917, on Dams; Relazione Fantoli.

Page 28 line 18 (Orig. p. 25) — See discussion by Engineer Galloway on O'Shaughnessy's paper Morena Rock Fill, A.S.C.E. 1912.(quotation page 50).

Page 29 line 7 (Orig. p. 26) — Upper Otay Dam was a thin shell of arched concrete like Bear Valley in 1900.

Page 29 line 25 (Orig. p. 26) — For explanation of flood disasters to Dams, see Engineering News March 9, 1916.

Page 31 line 12 (Orig. p. 28) — Refers to freedom of concrete dams from earthquake damage.

Page 32 line 10 (Orig. p. 29) — See Atlas San Francisco folio, U. S. Geological Survey, (1914).

Page 32 line 12 (Orig. p. 29) — The latter was uninjured by the earthquake, a careful examination having failed to reveal a crack in the splendid structure.

Page 39 line 15 — Within recent years an new style of dam has come into use in the Western States of the Union.

Page 40 line 24 (Orig. p. 35) — See Schuyler - Reservoirs for Irrigation, 1897, and 18th Annaul Report U.S. Geol. Survey, pp. 626 - 756; Walnut Creek Dam, page 722.

Page 41 line 8 (Orig. p. 36) — See Schuyler's Hydraulic Dams, 2nd. edition, 1898.

Note 1, p. 59, and Note 1, p. 61, (Original) omitted in translation.

Page 25
line 1
(Orig.p. 22) Total volume. See Mendes Dam, Eng. News, April 25, 1912.

Page 26
line 7
(Orig. p. 25) Lombardy, 1917, on Dams; Relazione Puntoli.

Page 26
line 18
(Orig. p. 25) Paper Geneva Book XIII, A.S.C.E. 1912. (quotation page 30).

Page 29
line 7
(Orig. p. 26) Lino Dear Valley in 1909.

Page 29
line 25
(Orig. p. 26) Engineering News March 9, 1916.

Page 31
line 13
(Orig. p. 28) damage.

Page 32
line 10
(Orig. p. 29) Survey. (1914).

Page 32
line 13
(Orig. p. 29) examination having failed to reveal a crack in the

splendid structure.

Page 39
line 18
See in the Western States of the Union.

Page 40
line 24
(Orig. p. 35) 18th Annual Report U.S. Geol. Survey, pp. 826 - 830;
Walnut Creek Dam, page 122.

Page 41
line 8
(Orig. p. 36)
See Schuyler's Hydraulic Dams, 3rd. edition, 1909.

Note 4, p. 34, and Note 1, p. 81. (original) omitted
in translation.

Comments on Professor Fantoli
by
M. M. O'SHAUGHNESSY

I have read Professor Fantoli's book, his statements and quotations, with a great deal of interest. He is laboring under a misconception that any contention is made in the United States for rock fill dams that they will survive flood conditions without adequate by-pass spillways. No such claim has ever been made for rock fill dams by myself or any proponent. The claim is made, however, that they will survive longer than an earthen dam when submerged by overflows over the top of the crest.

The Lower Otay Dam, which failed in January 1916, was not a true rock fill dam, as it was full of muck and earth all through the rock, and when an unprecedented flood of 30,000 second feet - from a watershed of 100 square miles - came, which submerged the spillway of only 5,000 second feet capacity, the other 25,000 second feet of flood went over the crest of the dam, washed away the slender triangular support to the steel plate core at the center of the Lower Otay dam structure. The resulting effect was that after the withdrawal of the rock and earth support the steel plates opened like gates ajar and the flood from the Lower Otay reservoir went down the valley to the Bay of San Diego.

I examined the Morena Dam some time after the flood and got the statements of the natives and people who lived in the vicinity, also secured photographs of the condition of the dam before flood and after. Those photographs disclose the fact that a wooden horse runway for saddle horses had been built across the mouth of the spillway, 120 feet wide by 8 feet deep, in front of the radial gates which controlled the spillway entrance. This resulted in stopping all the brush and trees which floated down under the flood action of the storm and blocking the whole or 75 per cent of the capacity of the spillway, as the wooden structure was

directly in front of the gates and squarely across the spillway channel. This resulted in raising the water in the lake so that it topped the crest of the dam possible 1 or 2 feet. This topping had no effect on the Morena Dam as the water percolated down through the rock structure. As this dam was properly constructed on very easy slopes, with a berme, there was no soil to wash away, hence there was no failure at Morena.

Rock fill dams have their place in industrial development as well as masonry dams, earthen dams and buttressed arch dams, and as I have built types of each kind successfully, I do not claim to be a proponent of any particular type. I do claim, however, that a rock fill dam, when built with care and workmanship, should survive just as long as any masonry dam, provided adequate spillways are made to by-pass the unexpected floods which come.

(Signed) M. M. O'SHAUGHNESSY

City Engineer, San Francisco, California
Civil and Consulting Engineer
October 1920

directly in front of the gates and squarely across the spillway channel. This resulted in raising the water in the lake so that it topped the crest of the dam possibly 1 or 2 feet. This topping had no effect on the concrete face as the water percolated down through the rock structure. As this dam was properly constructed on very easy slopes, with a berm, there was no soil to wash away, hence there was no failure at Hebron.

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