twenty-two years had kept its black metallic surface. (T. A. V. C. E., Vol. XXXI., p. 467.)

Referring to some concrete foundations that I built about ten years ago, the president of Star & Co. writes, as follows, under date of December 30, 1893: "Though this foundation is on tide land and submerged in salt water more than half way up, there is no rusting or deterioration to the iron. We had occasion to cut through one of the arches and found the iron as stated." A long time ago I imbedded a dozen pieces of hoop iron in as many blocks of concrete, leaving one end of each piece of iron projecting from the surface. After years of exposure to sea air, all the exposed iron had rusted away, or so nearly as to leave but a few soft, jagged needles of rust that were readily removed by the hand. In all cases upon cutting into the blocks I found the iron almost as good as new, and from one to two inches from the surface it was invariably so.

SECTION D.—*Water.*—The water for mixing should be clear, and by preference soft. If it cannot be obtained of ordinary purity, then due allowance should be made for the impurities by an additional quantity of cement.

Sufficient water should be used to bring the mass when thoroughly mixed into a stiff, sticky, tenacious, viscuous condition. An error as to the amount of water that should be used in concrete some years ago crept into the professional practice both of engineers and architects, and with surprising rapidity permeated and revolutionized it. I allude to the erroneous theory that only sufficient water should be used to slightly moisten the mass, and hardly enough to render it cohesive in its uncompacted state.

An error seldom takes the hold this did upon a skilled body of men without some apparent justification. The only justification that I have been able to find after considerable research is the fact that, in making briquettes for testing purposes, the use of a minimum quantity of water gives the best results. From this one little isolated fact the generalization was made that, to produce the best results, concrete should be mixed in like manner. The fatal flaw in this deduction lies here, viz.: that a mixture of cement, or of cement and sand, with water, differs radically in conditions when to either of these gravel is added, and differs yet more when broken stone is used.

If cement, or cement and sand, is mixed with a large proportion of water, it cannot be compacted by blows or such pressure as can usually be brought to bear, for the mixture would flow from under the tamper. In the latter case, however, where gravel or broken stone is used, with a larger proportion of water, the concrete can be compacted more intimately and closely than with the minimum quantity, and under all ordinary conditions makes a much better concrete. The only exception to this is where smooth, rounded pebbles only are used with the mortar of the concrete, but this exception does not apply to ordinary gravel and never applies where broken rock is an ingredient. I allude to this at some length, because the error, although on the wane, is still widespread.

DIVISION 3.—*Tools.*—There is great advantage and economy in mill mixing. Mills can now be obtained at a reasonable figure and should always be used on large works. By their use the cement is more fully utilized, the cost of labor lessened and the work is more uniform and satisfactory in character.

An objection is often made to mill-mixed concrete, viz., that the concrete is injured by overmixing. What is "overmixing?" A very rare *distemper*, this. I have never once met with it, although I have been actively engaged in concrete construction for thirty-five years. It is never epidemic or fatal, but like vaccination, if present, it would prevent worse and more fatal ailments.

Mr. Spencer Newberry found that a mixture of one of cement to three of sand, which when worked for one minute with a trowel developed a tensile strength of 87 pounds in seven days, developed a strength of 240 pounds in same period after being worked with the trowel for five minutes; a remarkable result, surely, and well worthy of consideration.

Contrary to the almost universal opinion, Portland cement is improved by a delay between mixing and placing. I have experimented with several brands of Portland cement and find that they were invariably improved in tensile strength by a delay of from one to four hours between mixing and placing.

In placing concrete it is preferable to have it of one uniform consistency throughout the mass. In cases, however, where it is required that the face of the work should be of a finer grade, both grades should be carried on simultaneously, the face grade being placed up against the sheeting or mold a little in advance of the backing by means of a trowel or other convenient tool. In more careful work thin strips of iron about six inches wide and of any lengths convenient, may be set up on edge in the concrete parallel to and at any desirable distance from the face of the mold. The face concrete should then be inserted between the mold face and the iron while the backing is placed at the other side thereof. As each layer is put in the iron is drawn up a few inches, so that when the concrete is tamped the effect of the tamping is conveyed below the lower edge of the iron, and causes the two grades of concrete to become thoroughly united and monolithic.

The material should in ordinary cases be placed in thin layers, seldom greatly exceeding in depth the length of the largest aggregates used, and these layers should follow one after another sufficiently quickly so that one layer does not become stiff or partially set before the next is upon it.

Flat tampers should not be used for massive work except in the first and last layers of the day's work; thin or edge tampers should be employed. Wherever practicable the concrete should be compacted by rolling, in preference to tamping. It is cheaper and much more effective. I am not aware of its being done outside of my own practice, but it is certainly deserving of almost universal use. On large work steam rollers would be excellent.

It may be accepted as an axiom that concrete cannot be too thoroughly compacted, provided the action is not violent enough to bruise or crush the aggregate.

In massive or deep work, as it proceeds through the day, often the working surface becomes richer in mortar, when, and as often as this occurs, the mixture should be changed by adding thereto more of the larger aggregates free from fine dust, sand or gravel, until this fault is remedied. If on the contrary at any time the surface becomes open for lack of mortar, it should be immediately remedied by putting into the mixture a lesser quantity of the larger aggregates and not substituting anything in their place.

In a similar way the amount of water used in the mixings should be regulated, changing to more or less as the working surface appears too stiff or too watery. It should be firm under the tamper or roller and yet the mortar should be viscuous and unctuous to the touch.

The quantity required to produce this condition varies greatly, dependent upon the character of the aggregates, whether but slightly or very porous, and upon the age and character of the cement and weather.

Great care should be observed in joining the work of one day to that of the next. The last layer should be thoroughly compacted and left with a slight excess of mortar. It should be finished with a level surface, which, at proper time, as soon as sufficiently stiff, should be patted or stippled with a steel float so as to produce a surface studded thickly with little conical knobs. This surface should be kept wet throughout the night, and in the morning immediately before the application of the first layer of fresh concrete it should be covered with a wash consisting of a mixture of equal measures of Portland cement and air-slacked lime, mixed with water to the consistency of thick cream. This covering should be put on in excess and brushed thoroughly back and forth upon the surface so as to insure a close contact therewith, the excess being swept along just ahead of the fresh concrete until all the surface has been covered, when it should be removed.

When in place the concrete should be kept moist for as long a period of time as possible. When one bears in mind that the chemical action which causes the cement to harden can only take place in the presence of moisture, the importance of keeping the work wet is at once apparent.

In all concrete construction excepting subway and other works where the concrete remains permanently moist, provision should be made for the slow but certain shrinkage that takes place in the concrete as it becomes thoroughly dehydrated. The vertical shrinkage will take care of itself, as the weight of the building is in harmony with its movement. The horizontal shrinkage, however, is resisted by the inertia of the structure and the friction of its foundation. There are several ways to direct such shrinkage; that which I have found most feasible is to partially divide the wall at certain intervals, preferably over the windows where there are several in line, and to insert across the division a weathering strip of copper or lead.

Where the appearance of a straight division line on the face of the building would be objectionable, for instance a wall blocked off into ashlar face, I build this division straight and cause it to coincide with the line of the V recesses of the ashlar, marking in every other course, and I block out in the intermediate courses recesses opposite to the division line, and subsequently fill these recesses with concrete ashlars made and seasoned beforehand. By adopting the pattern of alternate long and short ashlars in every other course with long ashlars only in the immediate course meeting at the centre line of the short ashlars above and below them, there separate concrete ashlars may be made small, and the additional cost of their manufacture will be but trifling.

Apart from the question of appearance, some such division of the surface of a concrete wall is advisable for a two-fold reason: some defining line is needed at the juncture of each day's work at least, and by dividing up the surface by deep recesses into small sections, surface cracking is largely avoided.

In rerefence to this shrinkage of concrete, lest I should have unnecessarily alarmed you, I will state that in a building, the walls of which were 170 feet long and divided thus, it was nearly two years before any apparent shrinkage took place, and now it can hardly be observed by a minute examination of the division joints. No outsider, even though a careful observer, would be likely to perceive any effects of this slight shrinkage when thus controlled.

In situations where it is not possible to make shrinkage joints by a liberal use of twisted iron, shrinkage cracks can often be prevented.

THE RESISTANCE OF PORTLAND CEMENT CONCRETE TO THE DESTROYING ACTION OF FIRE.

By a misunderstanding, due to a windy interference (Mr. Stone tells me one of my letters was blown out of his office window), I find I am expected to speak on the protection concrete affords iron in case of fire.

There seems to be not so much data on this subject as one would desire. What little there is, however, seems to be in favor of concrete as a fire resistant.

It is generally understood that the artificial stone made with Portland cement concrete withstood the Chicago fire well. Some years ago the blacksmith's shop at the Bencia Arsenal, California, was burned out, leaving the outer walls standing. This was a brick building with granite door sills, free stone belt courses, with window caps and cornice of Portland cement concrete. I examined the ruins carefully. The granite was spoiled badly and broken into several pieces; the freestone was badly broken and injured; the brickwork was burnt out in the joints in many places, rendering the walls unsuitable, many of the bricks also being spoiled, whilst the concrete window heads, which had probably to bear the brunt of the fire on the outside, were but little injured; the surfaces had softened a little and were badly discolored, but they remained whole and strong.

Concrete bricks made of well-burnt clinker and lime by a process which converts the lime into a silicate of lime, thereby making it resemble a Portland cement in character, withstand the action of a hot fire and the subsequent sudden cooling by water better than any burnt brick, either common pressed or firebrick, that I could obtain in San Francisco, and I presume the same relative result would be obtained from most of the bricks of the several States.

I have repeatedly made the tests so severe that every burnt brick in the dozen or so tested at a time broke into two or more pieces, whilst under the same test the concrete bricks, beyond discoloring slightly, showed no change.

THE THERMIC EXPANSION OF PORTLAND CEMENT.

Bonnican Bonnicean is quoted as giving the expansion of Portland cement at 0,00000143 for 1 celsius, and iron is given at 0,00000145, which is practically the same.

Hyatt corroborates this in some careful experiments he made with loaded floors submitted to fire, in which the concrete-iron construction bore a red heat for several hours without injury.

Throughout Europe I believe hollow tile construction is almost unknown. Concrete floors are commonly used in fireproof buildings. The result of tests undertaken in Germany under Government supervision to ascertain the relative value of the ordinary building material, including brick work, places concrete at the head of the list as the best fine resistant.

If due regard is paid to the aggregate used, so that feldspar is avoided, and limestone also, where the structure is liable to prolonged hot fire, I think it will be found that Portland cement concrete is an excellent fire resistant.

PUBLICATIONS.

A new and artistic catalogue has just been issued by I. P. Frink, manufacturer of reflectors, New York, a copy of which will be sent on application to any of our readers.

"Industrial Agreements and Conciliation" are the tropics treated by the Hon. C. C. Kingston, Premier of South Australia, in the December of the Review of Reviews; the magazine is publishing a series of articles by leading Australian statesmen on questions of immediate interest to American readers.

The Pease Furnace Co., Toronto, have recently published an interesting catalogue, in which is fully described their heating system and the method of securing best results therefrom. Illustrations of public and private buildings heated by their system, and testimonials from persons having it in use, are likewise given.

Of the second edition of the Canadian Contractor's Hand-Book, Mr. Chas. Baillairgé, Architect and City Engineer, Quebec, expresses the following opinion: "A valuable work of most useful and suggestive memoranda and tables, and worthy of an analytical index—the Table of Contents" as given affording a very incomplete idea of the information conveyed."