Canvass White and Natural Cement, 1818-1834

by Harley J. McKee

"Natural cement" was used to construct the first 350 mile section of the Erie Canal in New York State. Canvass White was one of the early surveyor/engineers who realized their knowledge of construction and material was limited in 1817. White and others experimented with natural materials found in the ground near the Canal to produce a mortar "cement." He patented a "water-proof cement" which was used in construction of the Erie Canal.

The second article discussed the growth of the natural cement industry beginning with the excavation of the Erie Canal and discovery of natural cement rock on the site. Natural cement plants began springing up in New York in 1824 and spread to various locations across the country.

Keywords: aqueducts; **limestone;** locks (waterways); mix proportioning; **mortars** (material); **natural cement;** navigable canals.

The Erie Canal was built to connect the Great Lakes with the Hudson River, and thence Atlantic seaports; it extended from near Buffalo to near Albany. The Erie was not the first canal in the state but it was by far the most ambitious, being over 350 miles (563 km) long and utilizing 72 locks. Its general section maintained a depth of water of 4 ft (1.2 m), 28 ft (8.5 m) wide at the bottom and 40 ft (12.2 m) at the surface; the banks were of earth. Docks were 12 ft (3.7 m) clear in width and 90 ft (27.4 m) long. Those of the middle section of the canal had stone walls 6 ft (1.8 m) thick, on a foundation of hewn timber 1 ft (0.30 m) thick, over which were laid well-jointed 3 in. (76.2 mm) planks. The canal passed over a number of streams by means of wooden aqueducts supported on stone piers. "Natural cement" was employed in the mortar of these and other stone works, particularly the portions under water.[1]

After exploratory surveys had been made by James Geddes in 1808, the New York State Legislature, on 17 April 1816, passed a bill directing the preparation of plans and estimates. A Canal Commission was established to administer the work; they divided the route into three sections, the middle one extending from Rome to the Seneca River. This middle section was surveyed and laid out by Benjamin Wright as engineer; one of his assistants was Canvass White. Formal construction began just west of Rome on 4 July 1817. Contracts were awarded for quite short sections, the contracting parties being numerous; the state also advanced money for the purchase of tools and for feeding the laborers. Excavation of the channel was done first and the construction of locks and aqueducts followed. In May 1820 the middle section was navigable; before that time transportation was difficult. Timber and stone had to be brought to the site while the ground was frozen, each winter's hauling being proportioned to the estimated needs of the following warm season. Such conditions encouraged the canal builders to use materials which could be found in the near vicinity of the works.[2]

Native American engineers surveyed and directed the construction of the Erie Canal. Judge Benjamin Wright was a lawyer who taught himself to survey. In 1792 he had used a spirit level to lay out the Inland Canal, a short waterway near Rome, and in 1802 he directed the construction of several locks on Wood Creek; this was his preparation before being placed in charge of the middle section of the Erie Canal in 1816. He was made Chief Engineer of all New York State canals in 1817 and retained this position until 1828, acquiring a high reputation in his profession.[3]

Canvass White was born in Whitestown, Oneida County, on 8 September 1790. His grandfather had been the first permanent settler in Whitestown, a short distance west of Utica, New York, moving there from Middletown, Connecticut, in 1784. Canvass lived on the family farm as a boy and had access to only limited common school facilities. From 1807 to 1811 he worked for a Colonel Carpenter in a village store as clerk. To improve his health he shipped as supercargo on a merchant vessel, which sailed to Russia. The ship returned by way of England, and in spite of current hostilities it was allowed to proceed to New York, arriving in September 1812.

White resumed work for Carpenter for a time and then attended Fairfield Academy in central New York, studying mathematics, astronomy, chemistry, mineralogy, and surveying. He appears to have spent an academic year there, and carried his studies as far as the resources of the Academy permitted.

In the spring of 1814 he raised a company of volunteers and was commissioned lieutenant in Colonel Dodge's regiment, serving with distinction in the fighting around Fort Erie. White was wounded severely by a shell, but recovered and finished out his term of enlistment. He then went to Clinton, New York, and studied with a Dr. Josiah Noyes, also engaging in an unsuccessful chemical manufacturing venture of an undetermined nature.[4] In the spring of 1816 White applied for the position of surveyor on the Erie Canal; he was engaged as one of the assistants to Benjamin Wright, on the middle section. At this time he made the acquaintance of Governor De Witt Clinton, who took an interest in the young man.

Canvass White and the other engineers appeared to recognize how limited their knowledge was. White was not satisfied with the information he could secure from the books then available, and in the autumn of 1817 he traveled to England at his own expense to learn more about canal construction, being encouraged to do so by Governor Clinton. He traversed more than 2,000 miles (3218 km) of English canals on foot, examining their construction, securing accurate drawings, and purchasing modern surveying equipment, which he brought back on his return in the spring of 1818.[5] In view of White's inquiring nature and his recognition of the many problems to be faced in building the Erie Canal, he must have taken every opportunity to talk to engineers about materials, construction, and design of canal works. If he was not already familiar with the limes and cements of England, and the stones or earth from which they were made, he must have inquired into the subject, because the problem of mortar for the masonry of the Erie Canal was a troublesome one.[6] The Canal Commissioners were willing to take a chance on using common lime mortar; Benjamin Wright knew from his experience on the Inland Canal in 1792 that it was unsatisfactory and had recommended the importation of Tarras or Roman cement for the Erie.[7] The Commissioners made no provision for importing cement in the budget, however. During 1818 and part of 1819 stone was laid in common lime mortar, and the mortar gave "evidence of soon failing."[8]

The story of the discovery of natural cement rock in the town of Sullivan appears with numerous variations; I shall base this account on reports of the Canal Commissioners,[9] and note some significant statements from other sources. A report made 25 January 1819, covering the work of the previous season, mentioned difficulty in excavating certain portions of the channel between Rome and Syracuse, where "indurated clay" — presumably shale — gypsum, and limestone had been encountered. Of some of this stone the report said:

". . . we expect to make a very important use; as, by a number of small experiments, in which, after being thoroughly burnt and slaked, or ground, and mixed in equal portions with sand, it appears to form a cement that uniformly hardens under water . . . and this meagre lime-stone (is found), on sections 27, 31 and 37. . . . On the south side of the canal, the ground always rises, in most places gently, but in some abruptly. And, in these elevations, within 1 to 8 miles (1.6 to 12.9 km) of the line, are contained inexhaustible quantities of lime and sand-stone. The wants of the country have not yet required, that many quarries should be extensively opened. But, we found some of an excellent quality that had been. To such we have had reasonable resort: and we have been very fortunate in opening several new ones."

It appears that natural cement rock provided by canal excavation, as well as that quarried, were used, but I cannot say which was the first. According to Joshua Clark:

"The first works of masonry on the Erie Canal, were contracted to be done with common quicklime. Mr. Mason Harris, and Mr. (Thomas)[10] Livingston, of Sullivan, Madison County, entered into a contract to furnish a quantity of this lime for the construction of culverts, aqueducts, etc., on the middle section of the canal, be-

Chemical Analysis*

The chemical character of Canvass White's natural cement was established by an analysis, made in 1822 by Seybert, of a sample of the limestone used in its preparation. The analysis gave the following results:

Silica (SiO)	11.766
Alumina (Al_2O_3)	2.733
Iron oxide (Fe_2O_3)	1.500
Lime (CaO)	25.000
Magnesia (MgO)	17.833
Carbon dioxide (CO_2)	39.333
Moisture	1.500
	99.665

*From "Portland Cement Materials and Industry in the United States" by Edwin C. Eckel, *Bulletin* 522, United States Geological Survey, Department of the Interior, Washington, D.C., 1913.

tween Rome and Salina (later called Syracuse). They burned a large kiln and commenced the delivery of it. The purchasers, upon trial, found that it would not slack; all were greatly surprised who heard of the facts, and wondered at the singularity. The circumstances became common talk among all classes, in any way engaged in canal matters, and finally became known to the engineers, of whom Canvass White was one, and Judge Wright another, who took an interest in the affair. The article was examined, and the ledge from whence it was taken.[11] Dr. Barto (Andrew Bartow), a scientific gentleman from Herkimer County, was called upon to make experiments, to prove what this new substance should be. He came on, took some of the rough stone, and in the trip hammer shop of John B. Yates, at Chittenango, burned a parcel, pulverized it into mortar, and in Elisha Carey's barroom, in the presence of Messrs. Wright, White and several others, mixed it with sand, rolled a ball of it, and placed it in a bucket of water for the night. In the morning it had set, was solid enough to roll across the floor, and by Dr. Barto pronounced cement, not inferior to the Roman of Puteoli, or the Dutch Tarras of the Rhine."

White apparently continued experimenting and searching: "Mr. White devoted considerable time and money in making experiments, and in introducing this cement."[12] According to John B. Jervis, another canal engineer: "I well recollect his diligent examination of the stone quarries, and his experiments during his search for suitable material."[13] In 1820 Canvass White obtained a patent from the United States Government for his cement; this product had been used on all Erie Canal masonry structures, beginning in 1819, and its use continued after the patent was secured. On 18 February 1820, the Canal Commissioners reported:

"The water-proof lime, which has been used, during the past season, for most of the mason work done on the canal . . . Mixed with clean silicious sand and water, and well beaten, it constitutes a mortar, which will soon set, and thoroughly cement any work of stone or brick, in which it is used under water . . . We failed repeatedly in burning, pulverising and mixing it; but many trials have now shown us the way to succeed in all these operations. And all the masons in our employ, though for some time they were loth to use it, from an opinion which they uniformly entertained of its being of no value, now regard it as a discovery of the greatest importance. It sets much quicker, and becomes stronger in the air, than common lime mortar; and under water, where a common mortar will not set at all, it begins to set immediately, and in a few weeks acquires great hardness and tenacity. It may be quarried with the same labor as common lime stone, and is known to occur in the greatest abundance, in Madison, Onondaga, Ontario and Genesee counties; its color is a yellowish grey, before it is burnt, and burning inclines it to a buff. It is softer than common limestone, and when burnt, about 10 percent lighter. It will not slack, but must be pulverized by pounding or grinding, and when reduced to powder, its bulk is not materially increased. The quantity of sand mixed with it should be about half that of the lime in bulk. From its not swelling, by being pulverized — from the expense of grinding it, and from the greatly diminished quantity of sand it will bear, it will be at once perceived, that its use will always be attended with greater expense than that of common lime. Still it may be used, at a very small proportion of the cost of any other material now known to answer the same purpose."

Some 500,000 bushels (17,600 m^3) of this cement were used during the construction of the original Erie Canal.[14] Canvass White's patent entitled him to receive $0.04 per bushel on the manufacture of "water-proof cement" but it was not paid to him by suppliers for the Erie Canal, either because they believed that his right would not be sustained by the courts, or because they thought he would reach an agreement with the State of New York for direct compensation. The latter course was followed, but not until White had sued one Timothy Brown of Sullivan in the District court of the United States for infringement, and obtained a judgement for $1,700. Brown and other contractors then petitioned the State Legislature for relief, and White agreed to sell his patent rights to the State of New York for $10,000, although twice as much was due him, and he could have collected triple indemnity if he had wished to sue all of the infringers. Henceforth anyone was allowed to manufacture waterproof cement free in New York.[15]

Natural cement rock occurs in New York State along with other limestones in a band about 1 to 10 miles (1.6 to 16.1 km) wide, whose approximate course may be traced on a map by drawing a line through Buffalo, Batavia, Geneva, Auburn, Marcellus, Oneida, Oriskany Falls, Richfield Springs, Schoharie, Catskill, Kingston, Ellenville, and Port Jervis.[16] It varies considerably in composition, thickness, and acessibility; for this reason some deposits have been quarried much more than others.[17] The manufacture of natural cement consisted essentially of three operations: quarrying, burning, and grinding. Fortunately, facilities for all three were available in the vicinity where natural cement rock was discovered. Chittenango Creek in the town of Sullivan afforded water power for a number of mills; among them was a plaster mill built in 1818 by John B. Yates, for grinding gypsum, which was abundant nearby.[18] Here he engaged in the manufacture of "water lime" soon after its discovery. The firm of George K. Fuller and Joseph Clary also manufactured water lime in the village of Chittenango.[19] Canvass White established works at Chittenango, placing his younger brother, Hugh, in charge. According to one account this was begun in 1825, and the product was called White's Water-Proof Cement.[20] Joshua Clark gives what I think is an account of the first manufacture:

"The article was first burned for market in the Town of Sullivan, Madison County, one mile and a half west of Chittenango, in the fall and winter of 1818-19, on large log heaps. John B. Yates fitted up a mill for grinding it. Mr. White had the exclusive right of manufacturing and vending the article. The price ordinarily charged, was from $3.50 to $5.00 per barrel of five bushels. The barrels were lined with oiled paper and were made perfectly water tight."[21]

It remains to mention the later part of Canvass White's career. While working on the Erie he became famous as a canal engineer; after that he worked on the Union Canal in Pennsylvania, the water supply system of New York City, and Schuylkill Navigation Company, the Delaware and Chesapeake Canal, the Windsor locks and the Farmington Canal in Connecticut, the Lehigh Canal, and the Delaware and Raritan Canal. In the autumn of 1834 he went to St. Augustine, Florida, in the hope of improving his health; he died 18 December, a month after his arrival, and was buried at Princeton, New Jersey.[22]

In my opinion Canvass White deserves a great deal of credit for his discovery of natural cement rock in central New York. One cannot exclude the element of chance, but I am impressed by the knowledge and persistence which he and other canal engineers contributed to the search. They knew what they were seeking and how to recognize it. A contemporary book expresses very well the optimism they must have shared:

"That all the materials for making the different kinds of water-cements, except pozzolana, and perhaps except cellular basalt, exist in great abundance, in the United States, there cannot be a doubt . . . but the mineralogy of the United States is yet so imperfectly known . . . we have, however, it is believed, all the kinds of lime-stone; and the State of New York can furnish the several varieties. . . ."[23]

Only the briefest explanation can be given in these pages of the relation between White's cement and other materials of historic interest. Common lime, made by burning relatively pure limestone in a kiln, has been used in mortar from ancient times. Hydraulic lime results when the stone contains as little as 18 percent to 25 percent of clay; it will harden under water. White's natural cement was made by burning limestone containing more clay — about 30 percent — in a kiln and grinding the resulting clinker. Pozzolana used by the ancient Romans contained only a small percentage of lime; therefore, after the material found in nature was pulverized, lime was added. Portland cement was made in England by Aspdin in 1824 from an artificial mixture of ground limestone and clay, which he burned in a kiln and ground into powder; he named it after Portland stone because of the resemblance. In the modern sense of the term, portland cement is that made by improved methods after about 1850. References to use of portland cement in the United States before 1865 should be received with the utmost skepticism.

The term "cement" in the sense of mortar or the solidified material made with lime and broken stones goes back at least to the fourteenth century in England. The term "concrete" appears to have been applied to the final product in England by about 1815. Modern concrete contains aggregate — gravel or crushed stone — as an essential ingredient; I am as yet unable to trace its use.

References

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2. *Canal Laws,* passim.
3. *Memorial of Centennial Celebration of the Turning of the First Shovelful of Earth in the Construction of the Erie Canal Held at Rome, N.Y., July 4th, 1917* (Rome, N.Y.), passim.
4. Statement of chemical manufacturing from *The History of Cohoes, New York* (Albany, 1877), p. 265. Other biographical data from Charles B. Stuart, *Lives and Works of Civil and Military Engineers of America* (New York, 1871), pp. 74-90.
5. The Canal Society of New York has searched for these drawings, but they are not known to be in existence now. A canal boat model brought by White from England is owned by the Buffalo Historical Society; the first boat built for the Erie Canal is said to have followed this model.
6. White received specimens of stone and advice from John J. Hawkins, according to a letter dated 31 October 1825, written by Hawkins from London, to W. Strickland, and published in *The Franklin Journal and American Mechanics' Magazine I* (1826), 197-200.
7. *Centennial Celebration,* p. 54.
8. Testimony of Benjamin Wright, in *Canal Laws,* II, 215 ff.
9. *Canal Laws,* I, 406-411.
10. Name (Thomas) from Mrs. L. M. Hammond, *History of Madison County, State of New York* (Syracuse, 1872), pp. 669 ff.
11. Said to have been on the farm of T. Clarke, Esq., in the town of Sullivan. *Trans. of N.Y. State Agric. Sec.* XI (1851), 695 ff.
12. Joshua V. H. Clark, *Onondaga: or Reminiscences of Earlier and Later Times* (Syracuse, 1849), I, 65-66.
13. Noble E. Whitford, *History of the Canal System of New York* (Albany, 1906), I, 97.
14. Annual comptroller's reports (*Canal Laws,* II) list materials furnished, but do not always discriminate between common lime and natural cement, so an exact total cannot be made from them. Names of persons who furnished lime and cement, whether as manufacturers, dealers, or brokers, from the reports of 1821-1825, follow: "Bond & Harris, Asa Broadwell, Colby & Phelps, H. & I. Dodge, Wm. Farrand, Gorham & Mears, Zadock Hubbard, Richard King, John Lard, Hanford Olds, Clark Puffer, Ezra Smith, Oliver Teall & Bangs, Teall & Sears, Ebenezer Warner, Wheedon, Mille & Hughes,

Abel Withey, Hezekiah Beecher, Henry Brown, Farwell & Shoemaker, Morris & Warner, Sage & Gridley, Brown & Morris, S. Farwell, J. Norris, Dox & Hickox, C. White."

15. *Assembly Journal* (Albany, 1825).

16. Ries and Eckel, *Lime and Cement Industries of New York* (Albany, 1901), pl. 103.

17. Ries and Eckel, *Lime*, pp. 800-836, et passim.

18. Spafford, *Gazetter of the State of New York* (Albany, 1824).

19. John E. Smith (ed.), *Our County and its People, a Descriptive and Biographical Record of Madison County, New York* (Boston, 1899), pp. 317-318.

20. Daniel E. Wager (ed.), *Our County and its People, a Descriptive Work on Oneida County, New York* (Boston, 1896), pp. 81-82.

21. Clark, *Onondaga*, II, 66.

22. Stuart, *Lives and Works*, pp. 74-90.

23. *Treatise on Internal Navigation* (Ballston Spa, N.Y.: U. F. Doubleday, 1817), p. 130. This reference was furnished by the Onondaga Historical Association, to whom I am also indebted for the extensive use of the Association's library.

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Growth of the Natural Cement Industry*

The use of the Madison County cement on the canal stimulated search for other deposits of cement rock.

The first natural cement manufactured in Erie County was made in 1824 at Williamsville. In 1839 Jonathan Delano erected cement works at Falkirk, near Akron, making about 2,000 barrels of cement for the first year. He furnished the cement for the feeder dam at Tonawanda Creek and for the Genessee Valley Canal. In 1843 the business passed to the hands of James Montgomery, who increased the output to 10,000 barrels a year. The business afterward came into the possession of Enos Newman, a partner of Montgomery, and has been in his family ever since.

In 1854 H. Cummings & Son established a natural cement plant at Akron, which was operated for several years. This plant was succeeded by another, managed by sons of the founder. The Akron plant was sold to the Akron Cement Co. in 1871, and the Cummings brothers erected another plant about 2 miles west of Akron.

The first natural cement made within the present limits of Buffalo was manufactured in 1850 by Warren Granger. His plant was near Scajaquada Creek, just below the Main Street Bridge, in what is now Forest Lawn Cemetery. In 1874 Lewis J. Bennett commenced the manufacture of natural cement at Buffalo Plains, near Main Street. This establishment, which has been carried on continuously under the control of the Bennett family, is now incorporated as the Buffalo Cement Co.

Third among the districts in point of age came the Rosendale region of eastern New York, which, however, soon became first as a producer and has ever since maintained a high standard in both the quality and quantity of its output.

*From "Portland Cement Materials and Industry in the United States" by Edwin C. Eckel, *Bulletin 522*, United States Geological Survey, Department of the Interior, Washington, D.C., 1913.

The discovery of cement rock and the commencement of manufacture of natural cement in the Rosendale district took place apparently about 1825, though there is considerable uncertainty as to the exact date. The industry, however, did not develop so rapidly as might be supposed, for in 1843 W. W. Mather[1] referred to the immediate past as follows:

"When making the reconnaissance (in 1837), soon after the commencement of the geological survey, the business had but commenced, and there was no cement manufactured on the Rondout except at Lawrenceville, and there but few kilns were in operation. It was not then known to the inhabitants that the cement rock was abundant except at and near these quarries until some of them were then informed of its inexhaustible quantities. Even now few are aware of the great extent of the rock and still fewer understand how to trace out the situation of favorably located new quarries."

During the six years that had elapsed since 1837, however, the industry seems to have grown rapidly, for his final report (1843) Mather states[2] that 16 firms, working 60 kilns, were then operating in the Rosendale district. He estimated the product at 500,000 to 600,000 barrels per year, and notes that about 700 men were employed in the quarries, in the mills, and in handling the cement.

Soon after the industry had become established in New York, it was taken up in several other States. R. W. Lesley has pointed out the direct relation of the early natural cement industry to the canal construction, which was then so prevalent.[3]

"The first large public works built in this country were the canals, and the most necessary thing to build a canal was mortar that would hold the stones together at the locks or walls under water. Consequently, wherever canals were to be built there was a search for cement rocks, and all the earliest works in this country were established on the lines of the canals. Thus, on the Chesapeake & Ohio Canal were the Cumberland and Round Top Works; on the Lehigh Canal, the works at Siegfrieds and Coplay, Pa.; on the Richmond & Alleghany Canal, the works at Balcony Falls, Va.; on the Delaware & Hudson Canal, the large group of works at Rosendale and Kingston; and on the Falls of the Ohio Canal, the large aggregation of works about Louisville. From this fact grew the early package used in shipping cement in this country — the barrel — which was the package best adapted to water transportation; and it took many years to overcome the prejudice against any other form of package and to substitute the paper or duck bag for the barrel."

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2. Idem, p. 329.
3. *Cement Age*, vol. 7, 1908, p. 245.

The following table shows the dates of establishment of the natural cement industry in various localities in the United States between 1818 and 1901.

TABLE 1 — Dates of establishment of the natural-cement industry in different States.

State	Location	Date
California	Benicia	1860
Connecticut	Kensington	1826
Georgia	Howard	1851
Georgia	Rossville	1901
Illinois	Utica	1838
Indiana-Kentucky	Louisville	1829
Kansas	Fort Scott	1868
Maryland	Round Top	1837
Maryland	Cumberland	1836
Maryland	Antietam	1888
Minnesota	Mankato	1883
Minnesota	Austin	1895
New Mexico	Springer	1899
New York	Akron	1839
New York	Williamsville	1824
New York	Buffalo	1850
New York	Onondaga and Madison counties	1818
New York	Rosendale district	1825
New York	Howe's Cave	1870
North Dakota	Pembina	1895
Ohio	Defiance	1846
Ohio	Barnesville	1858
Pennsylvania	Williamsport	1831
Pennsylvania	Lebanon (?)	1825 (?)
Pennsylvania	Lehigh district	1850
Virginia	Balcony Falls	1848
West Virginia	Shepherdstown	1829
Wisconsin	Milwaukee	1875

This month in the ACI JOURNAL

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Program SUBWALL: Finite Element Analysis of Structural Walls

by Egor P. Popov, Dao Q. Le, and Hans Petersson

This paper introduces an efficient and refined special purpose finite element computer program, SUBWALL, for linear elastic structural analysis and design of complex reinforced concrete walls under arbitrary in-plane static loadings. An application of the substructuring technique as a means of reducing computer cost and increasing versatility in the use of finite elements for analyzing very large and complex structural walls is emphasized. Two detailed numerical examples are presented to illustrate the usefulness of the program in a design office.

Moment-Curvature Relationships for Concrete Beams with Plain and Deformed Steel Fibers

by Grant T. Halvorsen and Clyde E. Kesler

Failure of steel fiber reinforced concrete beams is typically characterized by cracking of the matrix followed by pullout of the individual fibers. To compare the behavior of concrete reinforced with plain and deformed steel fibers, moment-curvature relationships were determined experimentally for flexural specimens, 4 x 6 x 64 in. (100 x 150 x 1625 mm). Two fiber contents with each of six fiber geometries were used. The results indicate that the post-cracking resistance may vary considerably, depending on the fiber ductility and the failure mode of individual fibers, as well as fiber content. Clearly, fiber reinforced concrete cannot be adequately described by strength alone.

Behavior of Concrete Block Masonry Under Axial Compression

by Robert G. Drysdale and Ahmad A. Hamid

The results of 146 axial compression tests of concrete block masonry prisms are reported. The results show that the strengths of grouted prisms are not affected much by the mortar joint. The average compressive strength for grouted prisms was less than for similar ungrouted prisms indicating that the concept of superposition of the strengths of grout and the ungrouted prism is not valid. An explanation for this phenomenon is suggested which indicates that the incompatibility of the deformation characteristics for the grout and the block contributes to this result. It is shown that the larger lateral tensile strains in the grouted prisms correspond to vertical compression strain levels in the grout which are associated with extensive microcracking and greatly increased Poisson's ratios. It is argued that this large lateral expansion of the grout leads to a premature tensile splitting failure of the blocks' shells. It is also shown that increasing the grout strength is not an efficient means for increasing the masonry compressive strength.

Summary of Research and Design Philosophy for Bearing Wall Structures

by A. W. Hendry

Following the Ronan Point accident in 1968 a considerable amount of research work was carried out in the United Kingdom to assess the liability of bearing wall structures to progressive collapse. This included tests on full-size structures and on load-bearing elements. These investigations are summarized in the paper together with a discussion of the measures developed to prevent the occurrence of progressive collapse in bearing wall structures at the design stage.

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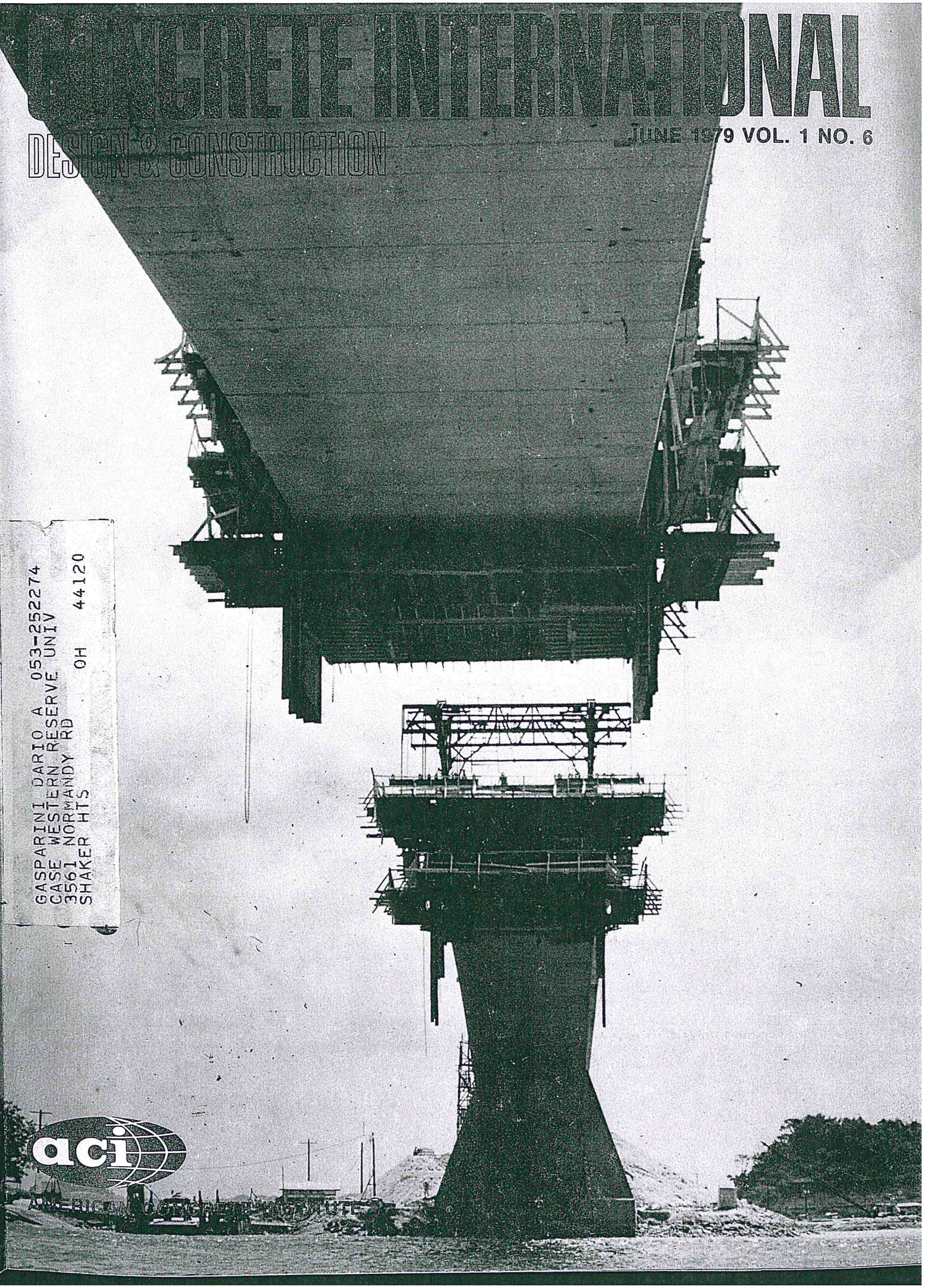

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