

VERDICT OF CORONER'S JURY
IN ST. FRANCIS DAM INQUISITION

STATE OF CALIFORNIA,)
County of Los Angeles.) ss.

IN THE MATTER OF THE INQUISITION UPON THE BODY OF

JULIA RISING, (Louis Garcia, William Y. Weinland, Marvin Caspress, Frances Ruth McIntosh Hopp, Richard Earl Pike, Donald Ferrell Hopp, Nellie Hanson, Kenneth H. Coe, John Parker, Richard Allen Pike, Carl James Mathews, Jr., Eva Holt, Mazie Curtis, Solomon J. Bird, Roland Errotchina, Thelma Mathews, Leona Johnson, Vida Mathews, Millie Mathews, Edward P. Price, Griffith O. Hughes, Rosaria Ruiz, Frances Garcia, Rosaria Errotchina, George A. Mann, William W. Neilson, Jr., Lyman W. Curtis, Oramae Beverly Berry, Alberta Isaac, William W. Neilson, Sr., Tootsie Garcia, Margaret C. Ely, Eugene M. Frazer, Deloris Rising, Adeline Rising, June Beverly Hughes, Elenor Rising, Reba M. Kennedy, Dorothy Fay Mathis, Max Bowsky, Charles Eugene Kennedy, Lois Bessie Burns, Ethel Elizabeth Cochems, Ella Della Vinson, Harry Garcia, William Thomas Stroud, Carita Holsclau, Pauline Kennedy, Un-identified Jap, Carlos Alvarado, Belen Alvarado, Joachim Klieman, Homer C. Coe, Ellen Crosno, Carmen Alvarez, Billie McIntire, Henry Joseph Voelker, Bertha Jane Neilson, Un-identified boy, White, 4, Frank A. Neilson, A. Thomas Kennedy, Dorothy Caroline Mathis, Louie Martin Burns, Ina Rebecca Weinland, Howard Thomson, Charley Mathews, Cecelia M. Small, Jane Doe, about 75, Clara Wilmot, Raymond Ross Wilmot, Velma Fay Wilmot, Nora F. Coe, Robert Kaderadek, Timothy Andrews, Ferrell Hopp, Clinton M. Anderson, Barbara Ellen Hughes, Jack M. Ely, Carl J. Mathews, Sr.) Deceased,

Before FRANK A NANCE, Coroner.

We, the Jurors summoned to appear before the Coroner of Los Angeles County at the CORONER'S OFFICE, HALL OF JUSTICE, LOS ANGELES, CALIFORNIA, on the 21st day of March, A. D., 1928, to inquire into the cause of the death of JULIA RISING, et al, having been duly sworn according to law, and having made such inquisition and hearing the testimony adduced, upon our oaths, each and all do say that we find that the deceased was named JULIA RISING, (et al) a female, married, a native of Minnesota, aged about 29 years, and that she came to her death on the 13th day of March, 1928, by drowning and other injuries, caused by the failure and destruction of the St. Francis Dam, and we find that her death was accidental.

CONCLUSIONS

After carefully weighing all of the evidence, that has been presented, we have reached the following conclusions:

1st. The St. Francis Dam was defective due to the very poor quality of the underlying rock structure upon which it was built and to the fact that the design of the dam was not suited to inferior foundation conditions. The actual failure was caused either wholly or in part by these defects.

2nd. The construction of this dam, without having the design and foundation conditions passed upon by independent engineers and geologists, and without more thorough and systematic methods of design, supervision and inspection, involved two basic errors.

One of these was an error in engineering judgment in determining the character of the foundations at the St. Francis Dam site and deciding upon the best type of dam to build there.

The other was an error in regard to fundamental policy relating to public safety.

The responsibility for the error in engineering judgment rests upon the Bureau of Water Works and Supply, and the Chief Engineer thereof.

The responsibility for the error in public policy belongs to those to whom the Chief Engineer is subservient, including the Department of Water and Power Commissioners, the legislative bodies of city and state, and to the public at large. It is a logical result of a set of conditions that the citizenship has allowed to develop and continue. This is the more fundamental error, for if proper safeguards had been provided in the city charter and in the state laws, making it impossible for excessive responsibility to be delegated to or assumed by anyone individual in matters involving great menaces

to public safety, it is unlikely that the engineering error would have escaped detection and produced a great disaster.

A sound policy of public safety and business and engineering judgment demands that the construction and operation of a great dam should never be left to the sole judgment of one man, no matter how eminent, without check by independent expert authority, for no one is free from error, and checking by independent experts will eliminate the effect of human error and insure safety.

The exemption of municipalities from supervision by state authorities in the building of dams involving public hazards is a very serious defect of the state law that should be corrected.

RECOMMENDATIONS

We respectfully recommend:

That the regulations governing the conduct of all municipal and county bodies engaged in building and operating dams be revised so that the construction and operation of all such dams will be subject to review by competent experts in addition to the regular executive engineering organization of the respective public bodies. It should not be left to the discretion of the Chief Engineer of such a body to submit such matters to experts, but should be mandatory upon the highest executive authority to employ thoroughly competent consultants that will not be subservient to the Chief Engineer.

That steps be taken to the end that all existing dams be thoroughly examined as to their safety by a board of boards of outstanding experts on the construction of dams.

That steps be taken to change the state law so as to place the building of municipal and county, as well as privately owned dams under the jurisdiction of the state authorities.

The intent and effect of these measures would be to have three independent groups of experts pass judgment upon the design, construction and operations of dams and other structures which might involve hazards to public safety.

We, the Jury, find no evidence of criminal act or intent on the part of the Board of Water Works and Supply of the City of Los Angeles, or any engineer or employee in the construction or operation of the St. Francis Dam, and we recommend that there be no criminal prosecution of any of the above by the District Attorney.

DETAIL REPORT

After visiting the site of the St. Francis Dam and hearing all evidence brought before us, we submit the following report:

DEFECTS RELATING TO DAM

The destruction of this dam was caused wholly or in part by the failure of the rock formations upon which it was built and not by any error in the design of section of the dam itself or defect in the materials of which the dam was constructed. The gravity section accorded with standard practice and would have produced a safe structure if it had been built upon hard, impervious rock as was supposed to be the case by those who built it.

On account of the great destruction wrought by the disaster and the absence of living eyewitnesses, much important evidence bearing on the cause of failure was obliterated, making it impossible to determine, with anything approaching complete accuracy, the exact cause of the initial break and the sequence of events thereafter.

However, there remains a large amount of very convincing evidence of a number of vital weaknesses in the bedrock and in the design with reference to its adaptability to a weak bedrock, any one of several of which weaknesses may have been the primary cause of the failure, and all did contribute to the terrific destruction wrought by the collapse.

The dam was in a defective condition due to the following:

1st. The dam was built upon two formations meeting at a fault contact which naturally caused a line of weakness across the axis of the dam.

2nd. The schist upon which about two-thirds of the mass of the main dam rested, is a weak material, badly shattered, very susceptible to seepage of water, and to slippage along the planes of cleavage.

3rd. The dip and strike of the planes of cleavage of the schist were at very unfavorable angles with reference to the lines of pressure of the dam and very favorable for landslides on the east wall of the site of the dam.

4th. The conglomerate upon which the western portion of the dam was built is variable in structure, badly seamed in several directions, and very deficient in bonding material. While it has the appearance of rock when dry, it is weak in compressive strength; and, when saturated with water, it disintegrates into a slippery mass of clay, sand, small pebbles and other included materials.

5th. Gouge materials at the contact between the two formations were inferior in strength to either of the two principal formations, causing a zone of weakness that can always be expected at such contacts.

6th. In addition to the contact fault there is another fault crossing the dam transversely and intersecting the contact fault about 150 feet downstream from the toe of the dam.

7th. The dam was not carried far enough into the bedrock and had no cutoff walls.

8th. There was no reinforcement or blanketing with concrete at the contact between the dam and the rock abutments, as is usual where the formations are not of the best. No pressure grouting of the bedrock was done.

9th. The dam was not provided with inspection tunnels with drainage pipes, discharging separately into the inspection tunnels for the purpose of locating any leakage and grouting it off if necessary. The only drainage pipes installed were confined to the center portion and connected to one manifold and outlet, making it impossible to localize leakage.

10th. The dam was built without predetermined expansion joints. This is a debatable question; but the best practice at present calls for their use.

METHODS OF DESIGN AND CONSTRUCTION

The St. Francis Dam was built by the Department of Water Works and Supply of the City of Los Angeles, by the City's own forces and not by contract.

The design of the dam and the foundation conditions were not passed upon by independent engineers and geologists.

The exploration work and testing of foundation materials prior to reaching a decision to build a dam at this site, were entirely inadequate to definitely determine the true qualities of the bedrock and the proper type of dam to build at the site.

The exploration work, both before and during construction, was practically limited to the boundaries of the concrete structure and did not adequately reveal the topography and character of the bedrock structure beyond these boundaries.

The inspection of the work during construction was very limited and defective in principle owing to the fact that the inspections were made by the same people who were directing or doing the work, without adequate check inspection by an independent personnel to reduce the effect of personal error.

Extensive exploration work, inspection and testing of materials and consultations with experts unquestionably would have revealed the true character of the site and prevented this calamity.

CONDITIONS IMMEDIATELY PRIOR TO FAILURE:

Even though the failure of the dam was either caused by or greatly assisted by saturation of the foundation materials with water from the reservoir, the total leakage that was observed at any time up to within a few hours of the failure was remarkably small, considering the critical condition existing under the dam, and less than is commonly present in dams that are considered safe and have stood for years.

There had been reports by subordinates and others who claimed to have observed increased leakage and muddy water coming from the dam a few days before the failure. In consequence of these reports, the Chief Engineer and his principal assistant inspected the dam about twelve hours before the failure and found that the water was coming out clear but picking up surface soil in flowing from the points of first appearance, to the afterbay pool below the dam. This agrees with the testimony of all witnesses who made observations at sufficiently close range to see the water where it first emerged from the ground.

The amount of leakage and its character were not such as to cause apprehension of those in charge of the dam and to cause them to doubt their previous faith in the safety of the structure. If they had concluded that the dam was in danger of destruction, the only safety measure possible at that time would have been to warn everyone in the possible path of the flood to move out, since, with all gates wide open, it would have taken many days to have drawn the water low enough to remove the danger.

There is ample evidence to show that no alarming symptoms were observed up to within 30 minutes of the first break, and that the entire destruction of the dam was completed in a very few minutes.

PERSONNEL:

The entire personnel of the Department of Water Works and Supply and the Department of Water and Power Commissioners, who were responsible for the building of the dam, appears to have had an unusual degree of confidence in the Chief Engineer and relied entirely upon his ability, experience and infallibility in matters of engineering judgment.

With a background of many years of very distinguished achievement in the building of a great water works system, including seventeen earth fill and rock fill dams, there was ample reason for a very high degree of confidence.

However, the Chief Engineer and his principal assistants had had limited experience in the building of large masonry or concrete dams prior to the building of the St. Francis Dam. Earth fill and rock fill dams are built wholly or in part on unconsolidated or yielding foundations, while masonry or concrete dams must have hard, impervious, unyielding foundations. This organization apparently did not appreciate the necessity of doing the many things that must be done in order to be certain that the foundation of a dam of the concrete gravity type is and will remain hard, impervious and unyielding.

As a consequence of these conditions, serious errors were made, while the entire responsible organization seemed confident that they were maintaining their previous high standard of accomplishment.

There appears to have been no disposition to neglect anything because of expense, as funds were available to meet any requirement deemed necessary. The only reasonable explanation is that those in charge were completely deceived as to the true conditions and acted through ignorance and not from intent to omit any precaution from any motive.

The exact sequence of these events is of great engineering interest but has little bearing on the question of basic cause and responsibility. A susceptibility to landslide was one of the defects of the site that should have been foreseen.

All of which we duly certify by this inquisition in writing, by us signed this 12th day of April, 1928.

(Signed)

Irving C. Harris

Foreman

Sterling C. Lines

Blaine Noice

Oliver G. Bowen

Chester D. Walz

Wm. H. Eaton

Harry G. Holabird

Ralph F. Ware

Z. N. Nelson

Approved:

(Signed) FRANK A. NANCE

Coroner