



**American Society of Civil Engineers**

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Testimony of

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Senior Vice President, DMJM+HARRIS (Ret.)

On behalf of the

AMERICAN SOCIETY OF CIVIL ENGINEERS

Before the

**Senate Environment & Public Works Committee**

April 18, 2006

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Mr. Chairman and Members of the Subcommittee:

Good morning. My name is Thomas Jackson, and I am pleased to appear before you today to testify on behalf of the American Society of Civil Engineers<sup>1</sup> (ASCE) as you examine the current status of the reconstruction of New Orleans' levees.

I am a past president of ASCE and currently serve on ASCE's External Review Panel, or ERP. The role of the ERP – which is composed of 14 specialists who possess a range of technical expertise – is to provide an objective, independent technical review of the Internal Performance Evaluation Team's activities which is carrying out an assessment of the performance of the flood-control levees in New Orleans following Hurricane Katrina.<sup>2</sup>

As engineers, our paramount concern is for the safety, health, and welfare of the public. We have learned a great deal from the tragedy of New Orleans, lessons that we hope will allow us to prevent future loss of life and property in Louisiana and elsewhere. We support federal, state, and local agency efforts to ensure that all infrastructure systems are (1) robust, i.e., strong enough and reliable enough to do the job; (2) contain

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<sup>1</sup> ASCE, founded in 1852, is the country's oldest national civil engineering organization. It represents more than 139,000 civil engineers in private practice, government, industry, and academia who are dedicated to the advancement of the science and profession of civil engineering. ASCE is a 501(c) (3) non-profit educational and professional society.

<sup>2</sup> Hurricane Katrina was a catastrophic storm that made landfall in the Gulf Coast near the Louisiana and Mississippi border with wind speeds near 150 mph. Flooding, not high winds, was the principal cause of damage in New Orleans following the failure of numerous levees in and around the city. For an analysis of the hurricane and its impact on the levee system in New Orleans, see THE AMERICAN SOCIETY OF CIVIL ENGINEERS AND THE NATIONAL SCIENCE FOUNDATION, PRELIMINARY REPORT ON THE PERFORMANCE OF THE NEW ORLEANS LEVEE SYSTEMS IN HURRICANE KATRINA ON AUGUST 29, 2005 (Nov. 2, 2005) at <http://www.asce.org/files/pdf/katrina/teamdatareport1121.pdf> .

redundant systems to prevent total system failure; and (3) are resilient enough to allow them to be quickly repaired when the inevitable failures within large, interdependent systems do occur.

Let me begin by saying that the lines of communication between the IPET and the ERP are functioning extremely well, and a good working relationship has been established. Since November, the ERP has provided the IPET with hundreds of comments, questions, and suggestions on a continuing basis. The IPET has considered all of the ERP's comments and most have already been incorporated into the IPET's work plan. We thank the IPET for its commitment to making good use of an independent review panel on a real-time basis to identify needed course corrections to ensure that the outcome is a robust, credible, and defensible performance evaluation.

The ERP is currently in the midst of its detailed review of IPET Report 2. This review follows on two-and-one-half days of meetings with IPET at the Engineer Research and Development Center in Vicksburg a little over a month ago. On March 23, 2006 we delivered a letter to General Strock, Chief of Engineers which noted several key concerns that the ERP has identified at this stage of the performance evaluation.

In general, the ERP finds that Report 2 represents an important, technically sound body of work. We are favorably impressed with many aspects of the studies that have been made, including the piecing together of information to present a clear picture of the physical events during Hurricane Katrina. We generally concur with the technical data, methods of analysis, and technical findings presented in Report 2. The ERP notes that particularly good progress has been made in several key areas including:

1. Defining the storm characteristics.
2. Hydraulic modeling of storms.
3. Linkage of eyewitness accounts, data, and computer modeling results.
4. Definition of a datum and vertical elevation adjustments relative to local mean sea level.
5. Investigation of failure mechanisms at the 17<sup>th</sup> Street Canal.

Two key factors identified by IPET apparently played major roles in the 17<sup>th</sup> Street Canal failure:

1. The formation of a gap between the sheetpile wall and the canal-side embankment as the water in the canal rose, which enabled development of full hydrostatic pressure against the wall. The formation of this water-filled gap was apparently not considered in design.
2. The presence of low-strength clay in the backyards on the protected side of the floodwall. Strengths used in design were apparently obtained from samples taken near the centerline of the levee, which had the benefit of significantly more overburden pressure than the clay layer in the backyards.

The ERP is looking forward to seeing the results of additional analyses, which are planned for the 17<sup>th</sup> Street Canal, including finite element modeling and additional centrifuge testing. The ERP is particularly encouraged by one of the key outcomes to date of the analysis of the failure at the 17<sup>th</sup> Street Canal – that is the development of a rational, analytical process that will enable a more reliable evaluation of the stability of other reaches of floodwall, particularly those that may show no outward signs of distress following Katrina and Rita. Clearly, the importance of hydrostatic loading and the need to adjust the strength of the clay to account for the effect of overburden pressure will be crucial to gaining confidence in the ability of other reaches of floodwall to withstand the loads that we saw during Katrina.

Since the recent meeting in Vicksburg, the ERP has taken the opportunity to review IPET Report 2 in greater detail. At this time, there appear to be a number of key lessons learned, which must be taken into account by Task Force Guardian, and in any analysis that looks to develop a system that will be able to withstand Category 4 or 5 hurricanes in the future. The ERP's immediate attention is focused on three main areas of potential lessons learned.

First, we are concerned about an apparent aggressive design approach, which may not have been warranted for a water-holding structure of this importance. It appears that at nearly every step of the way, the envelope was pushed. Let me explain. The target factor of safety was apparently 1.3 for design, which may be on the low side for structures whose failures were capable of causing death and widespread destruction. Against this backdrop, quite optimistic soil strengths were selected despite:

1. The fact that the local geology suggested that conditions would be highly variable, even over relatively short distances. For example, the analysis of the 17<sup>th</sup> Street Canal failure suggests that natural variations in soils strengths lead to factors of safety about 20-30 percent higher just north and south of the failure zone.
2. The fact that soil conditions and strengths were taken from widely spaced borings that were concentrated along the centerline of the levees.
3. The fact that soil strengths in the backyards were not adjusted to account for the reduction in overburden pressures.

In addition, the forces on the wall did not apparently include the possibility that full hydrostatic loads could develop through the formation of a simple gap caused by the wall moving away from canal-side embankment as the water in the canal rose above normal levels.

Second, there may have been problems associated with handoffs during the design process, or at interfaces between key players in the design. For example, were potential limitations in soil strength clearly communicated between the geotechnical team and the floodwall design team? Were concerns about hydrostatic loading on the wall clearly communicated and considered? How would the system have performed if the sheetpiles had been driven to greater depths?

Third, how was the Corps' quality assurance/quality control process followed during design? If, for a structure of this importance, techniques such as independent peer review or use of a Board of Consultants had been used, would the performance been different?

These concerns merit in-depth assessment to document lessons learned and to provide for ways to move forward that incorporate those lessons learned. The ERP will be looking into these matters.

In our review of IPET Report 1, the ERP commented on four critical areas that may go beyond IPET's scope. The ERP is pleased that the Corps is making progress on two these issues. First, the organizational complexities and lack of centralized, comprehensive management at the local, state, and federal levels are apparently being addressed. Second, issues associated with treating the hurricane protection facilities as a complex and inter-dependent system are also apparently being addressed. For example, closing off the three drainage canals and moving the pump stations to Lake Pontchartrain is a step in the right direction. The 17<sup>th</sup> Street Canal failure analysis certainly strengthens case for doing so.

The ERP is concerned that there has been apparently little progress on two other issues. First is protection from overtopping. The breaches were catastrophic, and some overtopping is far better than overtopping with breaching. The hurricane protection system needs to be resilient in a way that overtopping could occur without causing catastrophic failure.

Second, the ERP remains concerned about the way the system was conceived and developed. For example, how were life safety and risk factored into the design methodology, such as selection of the factor of safety? It appears that for the 17<sup>th</sup> Street Canal failure section, decisions made at several stages of the design process were played too close to the margins. By this I mean that assumptions and decisions were apparently not as conservative as they should have been, particularly given the grave consequences of the levee failure. In the end, the design did not adequately account for the uncertainties and variabilities inherent in such a complex system.

In summary, there are important lessons to be learned for flood protection systems in New Orleans and perhaps other cities and states. There are at least six key lessons to date:

1. Design methodology and selection of factors of safety for critical structures – what is the appropriate value for levees in the future?
2. Selection of soil strengths and accounting for variability.
3. The importance of water and considerations of hydrostatic loading.
4. Selection of sheetpile depths.
5. The need for clear communications at handoffs and interfaces.
6. QA/QC procedures and peer review.

Based on the findings discussed above, the ERP recommends the following actions be undertaken, with urgency, for levees and floodwalls in New Orleans and perhaps elsewhere in the nation:

- A. All I-walls should be re-evaluated for current design loadings assuming a water-filled gap along the flood side of the wall.
- B. All levees underlain by soft soils should be reevaluated for current design loadings accounting for reduced shear strength of soil in areas at or beyond the toe of the levee.
- C. All levees and floodwalls should be reevaluated to identify those areas with a questionable degree of conservatism inherent in the design process, and those sections of concern reanalyzed for current design loadings employing an appropriate degree of conservatism.
- D. A risk-based approach toward defining the design hurricane conditions is needed. We advise the Corps to proceed as quickly as possible toward redefining the standard project hurricane using principles and practices similar to those used in establishing design criteria for other infrequent but potentially catastrophic natural disasters such as earthquakes and floods.
- E. External peer review is an important component of design practice for all critical life-safety structures. We recommend that the steps described above receive external peer review throughout the design process.

In closing the ERP will continue evaluating IPET's Report 2, and will issue its own report in the coming weeks.. Thank you, Mr. Chairman. That concludes my testimony. I would be pleased to answer any questions that you may have.

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