Japan Seminar on Hurricane Katrina Disaster Reports

ハリケーンカトリーナの高潮･高波災害に関する日本セミナー

－A follow-up Seminar of the 2nd Int. Workshop on Coastal Disaster Prevention－
－第二回国際沿岸防災ワークショップフォローアップ会議－






Time and Date： 13:00－17:30　June 8, 2006
日時：　平成 18 年 6 月 8 日　13:00-17:30

Place： The Sasakawa Hall, 3-12-12, Mita, Minato-ku, Tokyo, Japan 108-0073
場所：　笹川記念会館　（〒108-0073 東京都港区三田 3-12-12）

Objective of the Seminar

Hurricane Katrina impacted the southern part of the United States on August 29, 2005, and became the most destructive natural disaster in American history. Comprehensive surveys and reviews of the Hurricane Katrina disaster were made in the United States. The Interagency Performance Evaluation Task Force (IPET) will publish a final report with the review of The ASCE External Review Panel. The lessons learned from the disaster should be shared throughout the world.

Japan is a country where integrated economic activities are concentrated in the coastal areas. The coastal areas have been attacked by typhoons and suffer from many storm surge disasters. The Second Workshop on Coastal Disaster Prevention was held in January, 2006, where comprehensive reports on coastal disasters, including the field surveys on the Indian Ocean Tsunami, were presented. The field surveys on extensive damage caused by Hurricane Katrina at the end of last August were also reported in the workshop. However, the detailed analyses of the disaster were not discussed in the workshop because the surveys had just started.

In this seminar, as a follow-up seminar of the workshop, the results of the survey by IPET will be explained. Dr. Billy L. Edge, Chairman of Coastal, Ocean, Ports and Rivers Committee (COPRI) of ASCE and Professor at Texas A&M University, Dr. Robert A. Dalrymple, Professor at Johns Hopkins University, Dr. Jeffrey A. Melby, Head of Coastal Structures Group of the U.S. Army Engineer Research and Development Center, and Dr. Peter G. Nicholson, Associate Professor at University of Hawaii at Manoa, are kind enough to visit Japan and discuss the matter at the seminar. Dr. T. Takayama, Professor at Kyoto University, and Dr. Masahiko Isobe, Professor at the University of Tokyo will present Japanese experiences of storm surge disasters in the seminar to encourage discussions between U.S. and Japanese sides. Simultaneous interpretation between English and Japanese will be provided.

Organizers：

Port and Airport Research Institute (PARI)
Coastal Development Institute of Technology (CDIT)
Japan Society of Civil Engineers（JSCE）

Co-sponsor:

Ministry of Land, Infrastructure and Transport, Japan（MLIT）

会議趣旨

昨年 8 月 29 日に発生したハリケーンカトリーナによる高潮･高波災害は自然災害として米国史上最悪であった．この災害の実態やその原因などについて，米国では種々の調査がなされており，本年 6 月 1 日には，IPET と呼ばれる米国土木学会等による災害調査タスクフォースの報告書が発刊される予定となっている．わが国の沿岸防災にとってもハリケーンカトリーナの災害は，学ぶべきことが非常に多く，本年 1 月 18･19 日に東京で開催された，第二回国際沿岸防災ワークショップでは，ハリケーンカトリーナの災害実態に関する緊急報告がなされた．しかしながら，調査が十分進んでいなかったため，災害の概要の説明だけにとどまっている．

本フォローアップ会議では，米国土木学会の海岸･海洋・港湾・河川委員会の B. Edge 委員長ほかを招き，ハリケーンカトリーナの高潮･高波災害に関するセミナーを開催する．セミナーでは，6 月 1 日に刊行される報告書の説明とともに，日本側から日本の高潮･高波災害に関する報告を行い，これからの沿岸防災のあり方についても意見を交換する．なお，会議は同時通訳によって日本語と英語で行う．

主催：
（独）港湾空港技術研究所
（財）沿岸技術研究センター
（社）土木学会
協賛：　国土交通省

Seminar Program

1. Opening ceremony 13:00－13:15

Session Chair: Mr. Yoichi Sakai, CDIT

Opening address Mr. Makoto Owada, President of PARI

Welcome Speech Professor. Masanori Hamada, President of JSCE

Welcome Speech Mr. Narikuni Nakao, Technical Counselor, MLIT

2. Presentations from Japan 13:15－14:05

Session Chair: Mr. Hiroyasu Kawai, PARI

Disasters in Japan due to Storm Surges and Waves

Professor Tomotsuka Takayama, Kyoto University

Future Storm Surge Control Measures in Areas below Sea Level

Professor Masahiko Isobe, University of Tokyo

3. Presentations from U.S. 14:15－16:15

Session Chair: Dr. Yoshimitsu Tajima, University of Tokyo

Summary of Hurricane Katrina

Professor Billy L. Edge, Texas A&M University

New Orleans after Hurricane Katrina: A First Look

Professor Robert A. Dalrymple, Johns Hopkins University

Failure of the New Orleans Levees – Geotechnical Issues

Professor Peter G. Nicholson, University of Hawaii

South Louisiana Comprehensive Coastal Protection and Restoration

Dr. Jeffrey A. Melby, U.S. Army Corps of Engineers

4. Panel discussion 16:25－17:25

Future prevention of storm surge disasters ; "Preparedness for the worst case."

Coordinator: Dr. Shigeo Takahashi, PARI

5. Closing Ceremony 17:25－17:30

Closing Address Mr. Susumu Murata, President of CDIT

会議内容

１．開会式　13:00－13:15

司会　沿岸技術研究センター　酒井洋一

開会挨拶　港湾空港技術研究所　理事長　小和田亮

開会挨拶　土木学会　会長　濱田政則

来賓挨拶　国土交通省大臣官房技術参事官　中尾成邦

２．日本側の発表　13:15－14:05

議長　港湾空港技術研究所　河合弘泰

日本の高潮･高波災害　京都大学教授　高山知司

ゼロメートル地帯の今後の高潮対策のあり方について　東京大学教授　磯部雅彦

３．米国側の発表　14:15－16:15

議長　東京大学　田島芳満

ハリケーンカトリーナ災害のまとめ　テキサス A&M 大学教授　Billy L. Edge

ハリケーンカトリーナ後のニューオーリンズ：最初に目にしたもの

ジョンホプキンス大学教授　Robert A. Dalrymple

ニューオーリンズの堤防の破壊－地盤的な問題　ハワイ大学教授　Peter G. Nicholson

南部ルイジアナの総合海岸防災と復興

米国陸軍工兵隊技術研究開発センター　Jeffrey A. Melby

４．パネル討議　16:25－17:25

今後の沿岸防災について；ワーストケースへの備え

コーディネーター：　港湾空港技術研究所　研究主監　高橋重雄

５．閉会式 17:25－17:30

閉会挨拶　沿岸技術研究センター　理事長　村田　進

Disasters in Japan Due to Storm surges and Waves

Tomotsuka TAKAYAMA, DPRI, Kyoto University, Kyoto, Japan, takayama@kaigan.dpri.kyoto-u.ac.jp

1. INTRODUCTION

Japan has suffered from disasters caused by storm surges and waves because she is surrounded by seas and located on the tracks of typhoons. The characteristics of storm surges in Japan are described in the paper. The past countermeasure projects against the storm surges are reviewed as an example of storm surge projects in Osaka. Future countermeasures are discussed through the recent storm surge disasters.

2. Past Storm surge disasters

The past major typhoons which caused big disasters in Japan are listed up on Table 1. The table shows that the big disasters took place in the three major bays of Tokyo, Ise and Osaka, and in the seas of Ariake and Suou. It also shows that the occurrence of these typhoons is divided into two periods before 1961 and after 1999. This concludes that the typhoons in the period between 1961 and 1999 have relatively small magnitude and create calm sea. The most miserable disaster was caused in the coastal area of Ise Bay by Typhoon No.15. The typhoon has been called Ise-Wan Typhoon since the disaster. After the disaster a permanent countermeasure project was established for each major bay. In the project storm surge barriers in each major bay were designed under the assumption that a big typhoon with the magnitude same as that of Ise-Wan Typhoon passed through on the track of the typhoon which caused the past highest storm surge in a bay of interest.

Table 1 Past typhoons which much affected Japan

Name of typhoon	Places	Anomaly (cm)	Death	Inundated houses
Taishou 6th (1917)	Tokyo Bay	230	1,127	302,917
Muroto (1934)	Osaka Bay	310	2,703	401,157
Sou-Nada (1942)	Sou-Nada	160	891	132,204
Makurazaki (1945)	Kagoshima Bay	>200	2,076	217,326
Jane (1950)	Osaka Bay	240	398	301,919
Ise-Wan (1959)	Ise Bay	345	4,697	363,611
2nd Muroto (1961)	Osaka Bay	241	194	384,120
Typhoon 10 (1970)	Tosa Bay	235	12	40,293
Typhoon 18 (1999)	Suo-Nada & Yatsushiro Sea	211	30	18,001
Typhoon 16 (2004)	Seto Inland Sea (Uno &Takamatsu)	160	16	44,935
Typhoon 18 (2004)	Seto Inland Sea (Hiroshima)	180	22	–

3. History of Countermeasure Projects for Mitigation of Storm Surge Disasters in Osaka

The coastal area of Osaka bay was much damaged in 1934 by the attack of the storm surge and waves generated by Muroto Typhoon. Though a project for countermeasure was started after the disaster, the project was not executed smoothly because of the plunge of Japan into the world war and the ground subsidence due to pumping-up of underground water.

In the waste state by the war Jane typhoon attacked Osaka and generated a large storm surge though the storm surge was smaller than that by Muroto Typhoon. Figure 1 shows the inundation area which reached to 30% of Osaka. A recovery project from the damage was established and seawalls were constructed along the sea front. However, the crowns of the seawalls went down by 0.4 to 0.8m from their original levels because of the ground subsidence. The reduced potential of the seawall protection enlarged the inundation damage in the following storm surge induced by Second Muroto Typhoon in 1961. However, fortunately the loss of human lives could be avoided because the fear of storm surge forced people in Osaka to refuge to safety places. Information of the storm surge reminded the people of the miserable storm surge disaster in Nagoya by Ise-Wan Typhoon of just two years before.

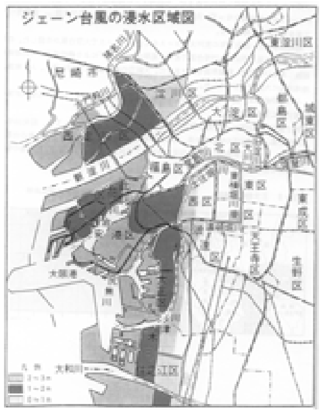

Fig.1 Inundation area due to Jane Typhoon in 1950

After the second Muroto Typhoon, more compulsory enforcement of the law which prohibited pumping-up of the underground water could stop the subsidence of the ground. The permanent countermeasure project against storm surge for Osaka was established in 1967, and has almost been completed. However, it is disclosed that the barriers constructed in early stage of the project have become old for work and have not been designed with sufficient quake-resistance.

4. Future Measure against Storm Surges

Storm surge disasters were much reduced in the three major bays by the execution of the permanent countermeasure project. However, storm surge disasters have recently occurred in different bays from them. Though these bays also have some storm surge barriers, the disasters were caused by the collapsing of the barriers. If the barriers had stood with the storm surge, the disaster would have been reduced. The water overflow rate is more than ten times increased by collapse of the barriers. Therefore storm surge barriers should not be easily broken even in the condition over the design.

5. Concluding Remarks

The permanent countermeasure project against storm surge was executed for three major bays. Consequently storm surge disasters were much reduced in the bays, but the storm surge barriers in the bays have become old for work. Furthermore, recent storm surge disasters have occurred in different bays from the major ones and have been enlarged due to the destruction of the barriers.

日本の高潮・高波災害

京都大学防災研究所教授　高山知司

1．はじめに

日本は海に囲まれ，台風の経路上に位置するため，高潮・高波災害に苦しめられてきた．本論文では日本の高潮の特性について述べるとともに，これまでの高潮対策事業について大阪湾における取り組みを例に紹介したい．また，最近の高潮災害を踏まえつつ，将来の高潮対策についても議論したい．

2．過去の高潮災害

日本に大災害をもたらした主要な台風を表-1 に示す．この表によると，大災害は三大湾（東京湾，伊勢湾，大阪湾）の他，有明海や周防灘にも起きている．また，これらの台風の発生時期は 1961 年以前と 1999 年以降の 2 つの期間に分かれている．すなわち，1961 年から 1999 年の間は，台風が比較的弱く，海も静穏であったと言える．最も悲惨な高潮災害は，台風 15 号によって伊勢湾沿岸にもたらされたものである．この災害によって，この台風は伊勢湾台風と呼ばれるようになった．また，この災害を契機に，三大湾ではそれぞれ恒久的な高潮対策事業が開始された．その事業では，それぞれの湾において，伊勢湾台風と同じ勢力の台風が，過去に来襲した台風の中でその湾に最大の高潮を発生させたものと同じコースをとった場合を仮定して，高潮対策施設が設計された．

3．大阪における高潮対策事業の歴史

大阪湾の沿岸では 1934 年の室戸台風による高潮・高波で多大な被害が生じた．この災害後から高潮対策事業が開始されたが，日本が世界大戦に突入し，地下水のくみ上げで地盤沈下が生じたため，あまり進捗しなかった．

戦争で荒廃した状態から抜け出す前に，ジェーン台風が大阪湾に大規模な高潮を発生させた．ただし，その高潮偏差は室戸台風のときと比べれば小さかった．図-1 はそのときの浸水域を示しており，その浸水域は大阪市の 30%に達した．この被害から復興する事業が行われ，海岸には護岸が築造された．しかし，地盤沈下で護岸の天端が元の高さから 0.4～0.8m 沈下した．このような護岸の防護性能の低下は，1961 年の第二室戸台風の高潮による浸水被害を拡大させた．しかしながら，大阪の人々には高潮に対する警戒心があったため，安全なところへ避難することで，幸いなことにも死者は免れた．高潮の情報は，人々にちょうど 2 年前の伊勢湾台風による名古屋の悲惨な高潮災害を思い起こさせた．

第二室戸台風の後，地下水の汲み上げを禁止する法律の施行が強化され，地盤沈下の進行は止まった．大阪湾の恒久的な高潮対策事業は 1967 年に開始され，今ではほとんど完成している．しかしながら，そこで築造された防潮堤はこの事業の初期の段階で築造されたものであるために老朽化しており，また，十分な地震耐力を持つ設計になっていない．

4．将来の高潮対策

三大湾では恒久的な高潮対策事業の実施によって高潮災害がかなり低減された．しかしながら，最近では三大湾とは別の湾で高潮災害が発生している．これらの湾にも高潮対策施設はあるが，それが破壊されることで災害が発生した．もし高潮対策施設が高潮で破壊を免れれば，もっと小さな災害ですんだであろう．高潮対策施設が破壊すると越流量は 10 倍以上に増える．したがって，高潮対策施設は，超過外力が作用した場合であっても簡単には破壊しないようにすべきである．

5．まとめ

三大湾では恒久的な高潮対策事業が実行された．その結果，高潮災害はかなり低減されたが，高潮対策施設は老朽化している．さらに，最近では三大湾以外の湾で高潮災害が発生しており，高潮対策施設の破壊が災害を拡大している．

(※) この和訳は事務局で作成したものです．正確なニュアンスは原文でご確認下さい．

Future Storm Surge Control Measures in Areas below Sea Level

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Panel on Storm Surge Control Measures was organized by the Japanese Ministry of Land, Infrastructure and Transport after the attack of Hurricane Katrina The panel issued a recommendation in January, 2006. In the presentation, it is introduced as shown in the contents below. This indicates the lessons learned from the Katrina disaster and future direction of storm surge mitigation systems in Japan.

Introduction
I. Basic aspects of storm surge control measures in areas below sea level
  1. Need of damage minimization against large-scale inundation
  2. Future storm surge control measures in areas below sea level
II. Specific measures to be taken
  1. Measures to fully prevent inundation through the existing storm surge defense plans
  2. Damage minimization measures against large-scale inundation
  3. Accumulation and dissemination of storm surge defense knowledge
  4. Additional challenge to be undertaken to ensure the security against storm surge disasters
Closing remark

Future Storm Surge Control Measures in Areas below Sea Level

(Recommendation)

January 2006

Panel on Storm Surge Control Measures in Areas below Sea Level

Contents

Introduction

Japan, surrounded by sea, has long been suffering storm surge disasters induced by large typhoons. Areas along the Pacific coast, three large bays, Tokyo, Ise and Osaka Bays, in particular, were severely hit by large typhoons such as Typhoon Muroto (1934), Typhoon Kitty (1949), Typhoon Ise-wan (1959) and Typhoon Daini-muroto (1961) and suffered heavy storm surge disasters. Typhoon Ise-wan incurred unprecedented damage throughout the Nobi Plains leaving more than 5000 people killed or missing.

Half a century have passed since the construction of levees in waterfront areas in the wake of Typhoon Ise-wan. In the meantime, many people have not been personally aware of the threat of storm surges because no serious storm surge disasters have occurred that claimed human casualties.

Hurricane Katrina induced large-scale storm surge disasters in New Orleans, the United States last August. More than 1200 people were killed or left missing. Seventy percent of the city of New Orleans is below sea level. The incident brought home that storm surges hitting places below sea level could cause catastrophic damage.

Areas below sea level that enclose the above three major bays of Japan* occupy a combined space of approximately 580 km2 and are inhabited by nearly four million people. These areas witnessed the concentration of people and assets in and after the advanced economic growth period and now play a central role in the country's social and economic operations. They are, however, highly vulnerable to flood disasters. Once the areas are inundated in water on a large scale due to storm surges, the nerve center of the country will be paralyzed causing an overwhelming social and economic impact.

Measures to control storm surges in areas below sea level are expected to focus on the construction of levees and other structures according to existing storm surge defense plans to ensure the prevention of inundation, in view of the present level of storm surge protection or the prospect for future natural disasters. Measures to minimize the damage by large-scale inundation are essential as a safety net against risk in contingency cases. Based on the above understanding, the study panel discussed future storm surge control measures in areas below sea level in

Japan and has provided recommendations as described in this report.

It is hoped that the recommendations will trigger various efforts for the future.

*Areas below sea level in the three major bay areas in Japan: Areas below the mean synodic high tide level

I. Basic aspects of storm surge control measures in areas below sea level

1. Need of damage minimization against large-scale inundation

Category 5 hurricanes had already caused heavy damage to New Orleans and surrounding areas in the Gulf of Mexico region, but levees had been designed only against category 3 storms. As a result, Hurricane Katrina with a magnitude far exceeding the design level incurred unprecedented damage.

In Japan, whenever storm surges caused damage greater than the design level, facilities were upgraded to enhance safety. In the areas below sea level in the three major bay regions, measures have been taken to control storm surges mainly by constructing facilities such as coastal or riverside levees according to storm surge defense plans against incidents of the class of Typhoon Ise-wan.

In the meantime, tides have risen to record high levels throughout Japan. Fortunately, however, the land below sea level in the three major bay regions has not experienced any disasters claiming substantial human casualties for nearly half a century. The areas have enjoyed social and economic development on a large scale based on the assumption of a high level of safety.

Judging from the above background, the scale of planning for and the progress of storm surge control efforts for the areas below sea level are considered to be generally adequate.

Some of the storm surge defense facilities constructed in the wake of Typhoon Ise-wan have long been in service and deteriorated or offer insufficient resistance to large earthquakes such as the Tokai, Tonankai and Nankai Earthquakes.

Storm surges are a natural disaster. Of concern are storm surges exceeding the design level or beyond the capacity of facilities under construction, simultaneous occurrence of storm surges and flooding, and combinations of multiple disasters such as storm surges right after a great earthquake. In the longer term, safety of coastal areas against flooding or storm surges due to rising sea level induced by global warming is likely to be deteriorated, and typhoons may gain greater strength.

Even where certain levels of facilities have been in place, the

possibility of unexpected events occurring cannot be eliminated completely.

Examples include levee breaches as a result of ships being washed away and crashing the levee or lock during storm surges and water spill through openings due to storm surges when neither floodgates nor locks can be closed.

Inundation owing to storm surges overtopping levees, unlike flooding resulting from riverbank overflow, causes floodwaters to continuously flow into areas behind the levee until the water level behind the levee becomes identical with the sea level. Inundation of the areas below sea level by storm surges is likely to cause serious damage because the areas may remain inundated in deep water for a long time and because evacuation may become extremely difficult.

Large-scale flooding of the areas below sea level around the three major bays of Japan due to storm surges will paralyze the nerve center of the country and have an overwhelming impact on its society and economy. New Orleans was inundated in water for more than a month and a half and some regions have yet to be provided with electric power and numerous residents have not yet returned home. This indicates the great socioeconomic impact of the large-scale inundation. Storm surge control in the areas below sea level should be regarded as a "national defense" measure because the existence of the country is at stake. The disaster defense poses a great challenge for administrative authorities.

Basic direction of storm surge control in the areas below sea level has been defined based on the above discussions. (i) Limited funds should be used mainly for steadily constructing storm surge defense facilities and securing their reliability in order to ensure inundation prevention according to storm surge defense plans. (ii) Measures should be taken to minimize the damage by large-scale inundation as a safety net against risk in contingency cases. In taking these actions, it is important to adequately reflect various lessons learned through the analysis of the Hurricane Katrina disaster in damage minimization.

Reducing damage to a minimum requires not only defense efforts of coastal or river administrators and port facilities managers but also self-protection initiatives of local communities. All the stakeholders should take a comprehensive approach that incorporates city planning, ways of living and individuals' disaster defense actions. The measures against large-scale flooding should focus on the protection of human lives and the continuation or early restoration of social activities.

2. Future storm surge control measures in areas below sea level

In future storm surge control, top priority will be given to ensuring inundation prevention according to existing storm surge defense plans. Appropriate involvement of national and prefectural governments is therefore required because they are responsible for coastal and river administration.

Damage will be minimized by diverse stakeholders. Organizations concerned including municipalities, coastal and river administrators and facilities managers should therefore jointly develop specific defense measures and risk management plans, disclose them in local disaster defense plans and reflect them in various local plans while considering how to keep stakeholders motivated. When defining actions for evacuation and information dissemination in particular, sufficient consideration should be given to people requiring guidance during a disaster such as the elderly.

Close coordination among administrative organizations and comprehensive implementation of disaster defense plans are necessary because measures are correlated to one another. Coordination among municipal governments in particular is essential.

In order to minimize damage, national and local governments and research institutions should collectively assume the type of damage by large-scale inundation and implement disaster defense measures while making a time-based verification of specific measures in terms of cost, feasibility and speed of project implementation for each region below sea level.

II. Specific measures to be taken

1. Measures to fully prevent inundation through the existing storm surge defense plans

The following measures should be taken to ensure inundation prevention through the existing storm surge defense plans.

(1) Steadily constructing storm surge defense facilities and securing their reliability

(i) Steadily constructing storm surge defense facilities

Coastal protection and river management facilities such as levees, revetments, floodgates and locks should be constructed more steadily than before. Priority should be given to securing designated functions of deteriorated facilities or facilities with insufficient seismic resistance. Construction of high standard levees (super levees) should be promoted in storm surge-prone sections of rivers designated to be provided with such levees, in the course of city planning.

(ii) Securing the reliability of disaster defense facilities

(a) Ensuring the inspection of storm surge defense facilities

Coastal and river administrators should make sure that inspections are made for the height, seismic resistance and degree of deterioration of facilities and the operability of floodgates and locks to secure the reliability of levees and other flood defense facilities.

(b) Planning and plan-based implementation of emergency measures

Based on the above-mentioned inspection results, emergency measures should be planned and implemented according to the plan for facilities that urgently require such measures.

(iii) Enhancing normal management system

(a) Enhancing inspection by coastal and river administrators and developing databases using inspection data

To ensure that disaster defense facilities operate smoothly, normal inspection by coastal and river administrators should be enhanced and databases containing inspection data should be used for plan-based maintenance.

(b) Reinforcing storm surge information collection and dissemination systems

Systems for coastal and river administrators to collect data on tide levels and water levels should be enhanced to encourage dissemination of accurate information to organizations involved in storm surge defense under normal conditions.

(c) Enhancing the efforts of flood fighting managers

Key flood fighting points should be specified in flood fighting plans for all of the coastal protection facilities. Organizations concerned constituting a flood fighting forum should check facilities in preparation for smooth flood fighting actions in the event of storm surges including the operation of floodgates and locks. The coasts as potential storm surge areas should be designated in accordance with the Flood Fight Law.

2. Damage minimization measures against large-scale inundation

Measures should be prepared to minimize damage in the case of large-scale inundation as a safety net against risks in contingency cases. Lessons learned from the Hurricane Katrina disaster should be reflected in disaster defense measures wherever they are applicable to Japan.

(1) Minimizing inundated areas

(i) Controlling water inflow to prevent inundation from expanding

(a) Constructing secondary levees and using highway and railway embankments, river levees and series of buildings

In order to prevent inundated areas from expanding and to drain floodwaters quickly, separating inundated areas into several sections using structures is considered effective. Examinations should be made of the construction of secondary levees, use of highway and railway embankments and river levees and waterproofing of openings between a series of reinforced concrete buildings using cutoff plates. Installing cutoff plates as part of flood defense activities needs to be considered.

(b) Taking measures for underground space

Measures should be prepared to prevent floodwaters from entering underground space such as subways and underground shopping malls and from spreading to other areas along subways or other paths.

(ii) Ensuring quick removal of floodwaters

(a) Ensuring drainage in the event of large-scale inundation

Quick drainage of floodwaters is essential to fast shift from temporary to full-scale evacuation and to early rehabilitation of local communities. Pumping stations along coasts, rivers or sewerage systems should be flood-proofed to keep them operational even where they are inundated in water on a large scale. Facilities driven by electric power should be equipped with in-house power generators to secure drainage during power failure.

(b) Developing optimal drainage plans

In order to ensure quick drainage, the capacity of drainage facilities should be assessed and optimal drainage plan should be developed. In the process, the plan should be made of improving the discharge capacity of existing floodgates and installing new floodgates in areas where drainage capacity is insufficient.

(iii) Ensuring quick restoration of storm surge defense facilities

Channels for transporting materials should be secured for quick restoration at locations of levee breaches. For levees used for material transport, crown width should be enlarged and continuously secured. In emergency situation those levees should connect to elevated highways and ports. Information should be promptly provided to the organizations concerned on port facilities available for material transport. Material sorting facilities should also be made available.

(2) Shifting to a way of living free from inundation damage

(i) Disseminating lively information on the hazard in individual areas

Preparation of hazard maps should be encouraged to communicate to residents in a plain form assumed modes of inundation and defense measures. Easy to understand information on local hazard should be provided to residents by disclosing water level information including the elevation of a given point, past floodwater depths and present tide level displayed on electric message boards, in urban areas. Then, residents should be encouraged to make preparations on their own.

(ii) Providing guidance to residents in reducing damage in conjunction with city planning

Hazard maps should be reflected in the development of policies for improving, developing or maintaining city planning areas. Residents should be advised to take hazard reduction measures by regulating land use through such means as the designation of potential hazard areas and the protection of urbanization control areas. Measures should also be prepared for underground structures. Damage reduction efforts should be made in conjunction with city planning.

(iii) Recommending structural design of buildings in preparation for inundation and for facilitating evacuation

Construction of buildings highly resistant to large-scale inundation should be encouraged by regulating land use through the designation of

potential hazard areas or by granting subsidies. For example, a part of building should be raised off the ground on pilotis, or an entrance should be equipped with cutoff walls. Building should also be structured to enable occupants to easily escape from it, e.g. to the roof.

(iv) Providing guidance to businesses in installing office equipment at appropriate positions

Guidance should be offered so that key office equipment including computers and power sources may be positioned properly to evade inundation damage. Appropriate use of buildings should be encouraged, for instance, people requiring support during a disaster should be dissuaded from occupying the bottom floor of a building.

Those handling toxic substances should be requested not to discharge them at the time of inundation.

(v) Advising residents to keep cutoff plates and sandbags on hand

Residents should be encouraged to keep cutoff plates and sandbags on hand by providing support including subsidies.

(3) Ensuring quick and safe evacuation and relief

(i) Ensuring shelters are operational at the time of inundation

Shelters should be set up for use during large-scale inundation disasters as well as earthquakes although existing shelters have been prepared against earthquakes. In the case where no shelters are available in the vicinity, elevated sections of highways such as service areas and parking areas should be used or buildings in the neighborhood should be designated as temporary shelters while paying attention to security concerns. Permanent shelters should also be made available that can accommodate evacuees once means of transport have been secured. Goods should be regularly stockpiled in temporary shelters considering the expected number of occupants and duration of stay. Efforts should be made to secure temporary shelters in designated areas or in their neighborhood to facilitate the evacuation of elderly people who will need support during a disaster.

(ii) Ensuring evacuation routes are passable at the time of inundation

Existing facilities, if they are to serve as emergency evacuation routes, need the height above floodwater level. Evacuation and relief channels should be secured that will be operational during inundation by widening levee crown and guaranteeing the continuity of levees, ensuring emergency access to expressways and constructing pedestrian decks connected to railway stations for use as evacuation routes. Equipping local communities with evacuation and relief boats is also important.

(iii) Disseminating information for proper evacuation guidance

The following measures should be taken to disseminate accurate information in an easy to understand format on expected mode of inundation and actions to be taken in specific regions with the view to ensuring public warning and evacuation operations.

(a) Reinforcing the dissemination of storm surge information

More accurate storm surge warning and more detailed information should be provided to the heads of municipal governments to help them issue evacuation recommendations. Easy to understand storm surge information should be made readily accessible via the Internet or cellular phones. More potential flood hazard coasts should be designated based on the Flood Fight Law to facilitate smooth flood fighting and evacuation.

(b) Preparing easy to understand storm surge hazard maps

Storm surge hazard maps should be prepared by coordinated efforts of municipalities that will help residents understand large-scale inundation hazard and actions to be taken. Hazard maps should also be developed for combinations of flooding and storm surges.

(iv) Disseminating storm surge information by all the means available

Storm surge information should be provided via every media accessible by residents including television, radio, the Internet, cellular phones, and car navigation systems usable under the Vehicle Information

and Communication System (VICS). Television is a key medium for people with limited information access including the elderly, so accurate information should be provided via the medium. Systems should be established to daily disseminate information to people requiring support in the event of a disaster by talking to them by coordinated efforts of the municipality and local community.

(v) Improving storm surge defense skills of the staff of municipal governments

The staff of local municipalities should be trained on storm surge defense to equip them with skills useful in the even of a large-scale inundation disaster and to have them share disaster fundamentals.

(vi) Developing risk management action plans

(a) Developing risk management action plans

In order to help organizations involved in storm surge defense, a local council that will be established by the organizations concerned such as national and municipal governments, and facilities managers for highways, railways and infrastructure systems including water supply and sewerage and power supply utilities should develop risk management action plans for large-scale inundation disasters. Risk management action plans should be specified in local disaster prevention plans and reflected in local planning. In the process, specific evacuation methods for each region should be examined.

(b) Holding disaster drills against storm surges

Disaster drills should be held in preparation for large-scale inundation by storm surges based on the risk management action plans. Then, efforts should be made to enable people requiring help during a disaster to be evacuated smoothly by talking to them. Drills should also be conducted to prepare for combinations of an earthquake and storm surges.

(4) Keeping facilities operational for rapid relief, restoration and rehabilitation

(i) Keeping lifeline systems operational at the time of inundation

(a) Keeping lifeline systems operational

Discontinuation of operation of lifeline systems due to inundation such as water supply and sewerage, power and gas supply, information communications and waste disposal facilities should be detrimental to rapid restoration and rehabilitation over a wide area. Operability of these facilities during a large-scale inundation disaster should be checked. Facilities should be water proofed if required according to plans for maintaining systems operability.

(b) Securing routes for relief and material transport for restoration

Securing routes for relief and material transport for restoration is essential to rapid relief, restoration and rehabilitation. Levee crown should be widened and the continuity of levees guaranteed. Emergency access to elevated highways and ports should be provided. Pedestrian decks connected to railway stations should be made available or constructed whenever required. Information should be promptly provided to the organizations concerned on port facilities available for transporting relief or reconstruction materials. Material sorting facilities should also be made available.

(ii) Preventing vessels moored to port from being washed away

Vessels and containers that are washed away by storm surges are likely to hit levees or revetments causing damage. Remedial measures should be developed such as quickly ensuring the safety of domestic or foreign vessels by moving vessels and containers to waters free from danger of crash, designating areas where no vessels or automobiles should be left unattended, removing vessels or automobiles that have been left and preventing cargoes stored in the open from being washed away.

(iii) Preventing the spill of toxic materials in waterfront areas

Removing toxic materials that are spilt from petrochemical facilities in waterfront areas and overflow levees is expected to require much time and hamper restoration and rehabilitation work. Businesses possessing or storing toxic materials should be guided to develop adequate plans to prevent the spill of toxic materials.

3. Accumulation and dissemination of storm surge defense knowledge

Memories of storm surges are likely to fade with time regardless of how serious they were. Knowledge about storm surge defense should therefore be accumulated and disseminated for use against future events.

(i) Accumulating and disseminating storm surge defense knowledge

(a) Preparing materials and developing human resources for accumulating and disseminating storm surge defense knowledge

In order to minimize damage, individual residents should take preparedness to inundation disasters personally. Easy to understand materials should be prepared to communicate the experience of elderly people in local communities to future generations and to accumulate and disseminate storm surge defense knowledge. It should be noted that past experience may lead to inadequate response under present conditions depending on the scale of the event. Human resources should also be developed that can plainly communicate the experience and knowledge to the public.

(b) Securing bases for disaster defense activities

Disaster defense bases should be established in local meeting places or other places for residents and administrative authorities to share storm surge defense information and for local residents to take defense actions through voluntary defense organizations.

4. Additional challenge to be undertaken to ensure the security against storm surge disasters

The following efforts should be examined to increase safety against storm surge disasters.

-Investigations and studies concerning the evaluation of structural strength of storm surge protection facilities against external forces
-Investigations and studies concerning the evaluation of probability of storm surge as a design external force
-Investigations and studies concerning the refinement of storm surge protection facilities inspection methods for their efficient maintenance, repair technology and deterioration control measures
-Investigations and studies concerning the development of methods for quickly restoring levees breached by storm surges
-Investigations and studies concerning protection measures against sea level rise due to global warming and land use in coastal areas
-Investigations and studies concerning disaster protection systems (including tax and insurance systems) in coastal areas

Closing remark

This document contains the first recommendations concerning storm surge defense in areas below sea level in the three major bay areas in Japan.

All the people involved in storm surge defense should be firmly aware that large-scale inundation of the areas below sea level would paralyze the nerve center of the country. The national and prefectural governments should take the initiative in developing and implementing as soon as possible specific action plans in accordance with these recommendations. Knowledge that will be obtained from further analysis of the Hurricane Katrina disaster should also be adequately incorporated into future measures.

The national and prefectural governments should also take the initiative in properly responding to specific problems to be encountered in future storm surge defense operations.

The Ministry of Land, Infrastructure and Transport, playing a central role in storm surge defense, should provide the public with information on the actions that organizations concerned have taken or will take in an easy to understand format. For example, if an increasing number of people understand that sea level rise due to global warming is a serious phenomenon that has a close bearing upon the lives and assets of people living in coastal areas, the public will take storm surge defense in the areas below sea level personally.

Storm surge defense in the areas below sea level as a "national defense" measure is related to the life and production activities of the public regardless of whether they live in coastal areas or not.

It is hoped that the recommendations will be used also as a basis for taking adequate measures in other areas below sea level according to the mode of land use or the concentration of population and assets although the recommendations have been made with the areas below sea level in the three major bay areas in mind.

Members of the panel on storm surge control measures in areas below sea level

Chairperson
Masahiko Isobe, Director, Graduate School of Frontier Sciences, University of Tokyo (coastal engineering)

Kohichiro Iwata, Professor, Chubu University (coastal structures)

Yoshiaki Kawata, Director, Disaster Prevention Research Institute, Kyoto University

Takayuki Kishii, Professor, Nihon University (urban planning)

Keiko Sakurai, Professor, Gakushuin University (administrative laws)

Tomotsuka Takayama, Professor, Disaster Prevention Research Institute, Kyoto University

Masami Tada, Edogawa Ward Mayor (local administration)

Atsushi Tanaka, Professor, Toyo University

Tetsuro Tsujimoto, Professor, Graduate School of Engineering, Nagoya University (river engineering)

Kazuyuki Higuchi, Deputy Director-General of Bureau of Port and Harbor, Tokyo Metropolitan Government (local administration)

Shoji Fukuoka, Professor, Research and Development Initiative, Chuo University (river engineering)

Yohichiro Fujiyoshi, NHK news commentator and Professor, Otsuma Women's University (mass communications)

Koji Yamamoto, Chairman, Halex Corporation (meteorology)
Note: Courtesy titles have been omitted.

ゼロメートル地帯の今後の高潮対策のあり方について

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ハリケーンカトリーナの災害の後，国土交通省では「ゼロメートル地帯の高潮対策検討会」を設置した. この検討会は 2006 年 1 月に提言を出しており，今回の講演では以下の項目について紹介する．その中には，カトリーナによる災害から学んだ教訓や将来の日本における高潮防災の方向性も含まれている.

はじめに
Ⅰ ゼロメートル地帯の今後の高潮対策の基本的方向
　１．大規模浸水を想定した被害最小化対策の必要性
　２．ゼロメートル地帯の今後の高潮対策の進め方
Ⅱ 推進すべき具体的施策
　１．これまでの高潮計画に沿って浸水を防止するための万全の対策
　２．大規模浸水を想定した被害最小化対策
　３．高潮防災知識の蓄積・普及
　４．高潮防災に関する更なる安全に向けての検討課題
おわりに

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Summary of Hurricane Katrina

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Hurricane Katrina was one of the most intense hurricanes to ever travel through the Gulf of Mexico and strike the US coastline surpassing hurricane Camille with the largest storm surge ever recorded along the Gulf coast. The City of New Orleans was besieged from all sides with the storm surge and waves. The storm produced wave and storm surge conditions for the New Orleans vicinity that were never before seen or ever expected in the designs for protection. The City is protected by a hurricane protection system (HPS) that is composed of many parts that do not all fit together well nor are they managed as a system.

Observed peak water levels along the south shore of Lake Pontchartrain were 10.8 to 11.8 ft, just under the height of the levee system in this location. Peak significant wave heights in this area reached 9.4 ft, exceeding design values by a foot or more. Along the east-facing hurricane protection levees in south Plaquemines Parish, peak water levels reached 20 ft, exceeding design levels by as much as 5.5 ft and design significant waves were exceeded by as much as 4.0 ft. During the storm, the HPS failed in many locations around the City and a very large part of New Orleans was flooded with depths up to 8 ft lasting for several weeks. Nearby the coasts of Mississippi and Alabama also received significant storm surge and waves and suffered near total destruction along the coastline. The storm surge at the coastline has been estimated to be in excess of 24 ft with depth limited waves. After nine months, this area and New Orleans still require significant recovery efforts. Moreover, the whole area impacted by the storm will be rebuilding for many years with a resulting character and population that will be much different than that before hurricane Katrina.

This storm has been described as the worst disaster in the history of the United States and a significant engineering failure. Approximately 1,577 died as a direct or indirect result from the storm in New Orleans and 170 from Mississippi. Flooding by hurricane Katrina is estimated to have caused over $25 billion in direct damages to property and infrastructure within the five parishes of greater New Orleans. This includes over $20 billion in property damages, of which over one-half represents damages to residential structures and the remainder is infrastructure.

Because of the intensity and consequences of the storm, three studies were commissioned by the US Government. The first was conducted by the Interagency Performance Evaluation Team (IPET) which produced a thorough study dealing with the storm, performance of the HPS, consequences and risks. IPET is using the combined skills of over 155 experts from government, academia and industry. The second was conducted by the External Review Panel (ERP) of the American Society of Civil Engineers; the ERP is charged with evaluating and validating the methods and analyses of the IPET. The third study is being conducted by the National Academy of Sciences and the National Academy of Engineering and it was created at the request of the Department of the Army to ensure an open and unbiased review of the study. This presentation will present a detailed analysis of the development of the hurricane and identification of the wave and surge events. It will give a comparison of the observations with the storm and with the design parameters used for the HPS surrounding the City. A brief discussion will also be given of the major findings from the IPET study and the ERP review. And in summary, a highlight of the current status of the City of New Orleans and the impacted Gulf Coast will be given.

ハリケーンカトリーナ災害のまとめ

テキサス A&M 大学教授　Billy L. Edge

ハリケーンカトリーナは，メキシコ湾を抜けアメリカ沿岸を襲った最大級のハリケーンであり，ハリケーンカミールを凌ぎ，メキシコ湾沿岸に史上最大の高潮をもたらした．ニューオーリンズ市にはあらゆる方向から高潮と高波が迫った．このハリケーンでニューオーリンズ周辺に発生した高波と高潮の状況は，かつて見たことのないものであったが，防御水準からは予期されていたものである．ニューオーリンズはハリケーン防御システム HPS によって守られている．このシステムは多くの施設から構成されているが，全てがつながっているわけではなく，一つのシステムとして制御されているわけでもない．

ポンチャートレン湖の南岸で観測された最高水位は 10.8～11.8 フィートであり，この水位はこの地点にある堤防をわずかに下回るものであった．この辺りの最大有義波高は設計値を 1 フィート以上上回る 9.4 フィートに達した．南のプラークマインズ郡にある東向きのハリケーン防護堤防では，最高水位が設計値を 5.5 フィート上回る 20 フィートに達し，最大有義波高も設計値を 4 フィート上回った．ハリケーンが通過する間に，ハリケーン防御システムはニューオーリンズ市周辺のあちこちで決壊し，ニューオーリンズの大部分が最大 8 フィートの深さで数週間も浸水することになった．ミシシッピ州やアラバマ州の沿岸部でも，激しい高潮と高波に遭い，海岸沿いでは壊滅的な打撃を受けた．この海岸では砕けながら押し寄せる波の影響もあって，高潮は 24 フィート以上に達したと推定されている．カトリーナの来襲から 9 ヶ月たっても，この地域とニューオーリンズでは復旧活動が必要とされている．さらに，ハリケーンの影響を受けた地域ではどこでも，長い年月をかけて復興がなされるであろうが，ハリケーンカトリーナが襲う前とは街の様子も人の数も全く異なったものになるであろう．

このハリケーンは，アメリカ史上最悪の災害であり，また工学における重大なる失敗と言われている．ニューオーリンズではハリケーンの直接的あるいは間接的な影響で 1577 名ほどが亡くなり，ミシシッピ州でも 170 名が亡くなった．ハリケーンカトリーナの洪水による被害は，大ニューオーリンズ市を構成する 5 郡だけの，資産とインフラへの直接的な被害に絞っても，250 億ドルに達した．そのうち 200 億ドルが資産の被害であり，その半分以上が住宅の被害，残りがインフラの被害である．

このハリケーンが非常に強く重大なものであったため，米国政府は 3 つの調査を命じている．一つ目は関係機関合同性能照査タスクフォース IPET が担当し，ハリケーンそのもの，ハリケーン防御システムの性能，被害状況，リスクに関して綿密な研究を実施するものである．この IPET には産学官の 155 名を超える専門家の技術を結集している．二つ目は，アメリカ土木学会 ASCE の外部評価委員会 ERP によって運営されているものであり，ERP は IPET の実施する調査の方法や解析結果の評価を担っている．三つ目は米国科学アカデミーと工学アカデミーによって運営されているものであり，陸軍省の依頼でその調査に対する開かれた公平な評価も行われている．この講演では，ハリケーンの発達に関する詳細な解析結果や，高波や高潮の状況について発表したいと思っている．ハリケーンの観測値とニューオーリンズを取り囲むハリケーン防御システムの設計値との比較もする予定である．IPET による調査と ERP による評価から見いだされた主要な事項についても簡単に議論したい．要するに，ニューオーリンズと被災したメキシコ湾岸の現状に主眼を置くつもりである．

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New Orleans after Hurricane Katrina: A First Look

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INTRODUCTION

After the failure of the hurricane protection system and the flooding of the City of New Orleans during Hurricane Katrina, a joint site visit team comprised of engineers and scientists were the first to examine the failed levees and floodwalls. This joint team, comprised of both civilian and U.S. Army Corps of Engineers members, visited a number of sites in the New Orleans area to gather data on possible failure mechanisms.

THE TRIP

Beginning on October 2, 2005, two team of engineers from the American Society of Civil Engineers' Institutes, COPRI and GEO Institute, joined a team from the University of California, Berkeley, and one from the Corps of Engineers, primarily from the Engineering Research and Development Center, to examine the failed levees and floodwalls in and around the City of New Orleans.

At the time, the failure of the hurricane protection system for the city was believed to be overtopping, as the system was designed for approximately a Category 3 (Saffir-Simpson Scale) hurricane, and it was believed, at the time, that the Hurricane Katrina storm surge exceeded the design water levels.

The hurricane protection system in New Orleans is comprised of levees, surrounding the city to protect it from Lake Pontchartrain to the north, Lake Borgne to the east, and the Mississippi River, which passes through the city, and floodwalls along the drainage canals that deliver water pumped from the city to Lake Pontchartrain. These canals are open to the lake.

At the outset of our inspection, which began with the 17th Street Canal, it was clear that the floodwalls had not overtopped at the canal and another mechanism was responsible. This was also true at the London Avenue Canal. Yet, at other locations in the eastern of the city, overtopping clearly occurred, such as along the Industrial Canal, which connects the Mississippi River to Lake Pontchartrain and the Mississippi River Gulf Outlet, a canal that goes directly from New Orleans to the Gulf of Mexico.

This presentation will show many of the floodwall and levee failures and discuss preliminary findings as to the failure mechanisms. It also will show that levees, at the proper elevation, and constructed well, did withstand the severe storm.

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ハリケーンカトリーナ後のニューオーリンズ：最初に目にしたもの

ジョンホプキンス大学教授　Robert A. Dalrymple

はじめに

ハリケーンカトリーナによってハリケーン対策システムが破壊され，ニューオーリンズ市が浸水した後，技術者や研究者からなる合同現地調査隊が初めて，決壊した堤防の調査を実施した．民間人と米国陸軍工兵隊員で構成されたこの調査隊は，ニューオーリンズの周辺のあちこちで，考えられる破壊メカニズムを検討するために必要なデータを収集した．

現地調査

2005 年 10 月 2 日から，米国土木学会の海岸・海洋・港湾・河川委員会 COPRI と地盤工学委員会 GEO-Institute の 2 つの技術者による調査団は，カリフォルニア大学バークレー校による調査隊，米国陸軍工兵隊の技術研究開発センターを中心とする調査隊に加わり，ニューオーリンズ市とその周辺で決壊した堤防の調査を実施した．

ニューオーリンズのハリケーン対策施設は，サファ・シンプソン・ハリケーン・スケールでほぼカテゴリー3 に位置づけられるハリケーンに対し，設計されたものである．そのため，調査を開始する時点では，この施設が越流で破壊したと信じこんでいた．また，ハリケーンカトリーナによって設計潮位を超える高潮が発生したとも信じこんでいた．

ニューオーリンズのハリケーン対策施設には，北に位置するポンチャートレン湖，東に位置するボーン湖，そして市街地を貫くミシシッピ川から，市街地を守るために市街地を取り囲むように築かれた堤防がある．また，市街地からポンチャートレン湖へポンプで排水する運河に沿っても堤防がある．これらの運河はポンチャートレン湖に開いた状態になっている．

我々の調査は 17 番街運河から始めたが，そこでまず分かったことは，「この運河では堤防の越流は生じておらず，他に何らかの破壊メカニズムがあるはずだ」ということである．ロンドン通り運河も同じであった．しかし，ニューオーリンズ市の東部に位置する別の地点では，明らかに堤防の越流が生じていた．ミシシッピ川，ポンチャートレン湖，Mississippi River Gulf Outlet（ニューオーリンズからメキシコ湾へ直接出るために掘削された運河）につながる工業運河がその例である．

今回の講演では，多くの堤防の破壊状況を紹介するとともに，破壊メカニズムに関して明らかになったことについて議論する．また，十分な高さでしっかりと築造された堤防については，このハリケーンでも破壊に至らなかったことを示したい．

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FAILURE OF THE NEW ORLEANS LEVEES – GEOTECHNICAL ISSUES

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INTRODUCTION

Hurricane Katrina was a major storm for the Gulf of Mexico and the Gulf Coast states of the U.S. However, it was not unprecedented nor was it the maximum storm which could strike the area. In fact, in a number of locations where failures occurred, design levels were in excess of the maximum storm surge created by Katrina.

It was expected and predicted that the high winds and anticipated storm surge would cause some damage and flooding as the storm made landfall and pushed inland. What was not fully appreciated was the consequences of a widespread failure of the Southeast Louisiana flood control system including New Orleans and surrounding areas.

INITIAL FIELD ASSESSMENT

The American Society of Civil Engineers (ASCE) organized an independent team of experts to travel to New Orleans to conduct early reconnaissance of the affected area and establish ties with the U.S. Army Corps of Engineers' (USACE) investigative team. The team from ASCE's Geo-Institute was joined by members of the Coasts, Oceans, Ports and Rivers Institute (COPRI) and a National Science Foundation-sponsored team, predominantly from the University of California at Berkeley. The initial objective of all of the teams was to collect data and make observations to be used to assess the performance of the flood control levees in an attempt to determine why certain sections of the levee system failed while others did not.

What was found in the field was very different than what was expected given what was reported in the media. Rather than a few breaches through the city's floodwalls caused by overtopping, the teams found literally dozens of breaches throughout the many miles of levee system. From a geotechnical perspective, it was very interesting that many of the levee problems involved significant soil-related issues. A number of different failure mechanisms were observed, including overtopping scour erosion, seepage and piping, and soil foundation failures.

The preliminary findings of the field assessment were presented to the US Senate Committee on Homeland Security and Governmental Affairs in November 2005 with a simultaneous release of a joint report by the ASCE and NSF teams.

TECHNICAL INVESTIGATIONS

Over the past several months a number of investigations have been undertaken to assess the technical details of the levee failures and to establish the current condition of the entire hurricane/flood control system. The largest of these investigations, the Interagency Performance Evaluation Taskforce (IPET) was organized by the U.S. Army Corps of Engineers (USACE), and combined the efforts of a wide range of experts from government, industry and academia. Additional independent investigations were conducted by the NSF/UC Berkeley team and Team Louisiana, sponsored by the State of Louisiana and spearheaded by members from Louisiana State University's Hurricane Center.

While each of these investigations had various goals and objectives, all have concluded that a number of the failures and subsequent resulting damage should have been preventable given the state of engineering knowledge. A number of systemic flaws have been identified and many lessons have been learned from this disaster, which will assist in improving the practices of critical hurricane protection for New Orleans and other developed regions around the world.

Technical reviews of these investigations are now being undertaken to validate the findings and then present to the general public.

ニューオーリンズの堤防の破壊－地盤的な問題

ハワイ大学教授　Peter G. Nicholson

はじめに

ハリケーンカトリーナは，メキシコ湾や米国メキシコ湾沿岸の各州を代表するハリケーンであった．しかしながら，このハリケーンの強さは予期せぬものではなく，この地域を襲った最強のハリケーンでもない．実際，被災地の多くでは，設計潮位がカトリーナによる最大高潮偏差よりも高かったのである．

「ハリケーンが上陸して内陸に進むと，強い風が吹いて高潮が発生し，それが破壊や浸水を引き起こすであろう」ということは予期されていたし，予測もされていた．あまり喜ばしくないことに，ニューオーリンズとその周辺を含む南東ルイジアナ洪水防止システムが広範囲で機能しなかったことが問題になった．

初期の現地調査

米国土木学会 ASCE では，被災地の踏査と米国陸軍工兵隊 USACE の調査隊との連携を目的として，ニューオーリンズへ向かう，自主的な専門家チームを素早く組織した．ASCE の地盤工学会の調査隊には，カリフォルニア大学バークレー校を中心に，海岸・海洋・港湾・河川委員会 COPRI のメンバーや全米科学財団NSFが後援する調査隊も合流した．何れの調査隊でも，洪水防止堤防の性能の照査に用いるデータの収集や観測を行うことを当初の目的としていた．そこには，「堤防が決壊したところとしなかったところがあるのは何故か」を突き止める意図があった．

現地に着いて分かったことは，メディアで報道され，思っていた状況とは，まるで違うということであった．調査隊が目の当たりにしたものは，市街地の堤防が数カ所で越流によって決壊したことよりはむしろ，何マイルも続く堤防が本当に数十もの地点で決壊していたことである．地盤工学の視点に立つと，この堤防の問題点の多くが土質に関係したものであり，非常に興味深かった．越流による洗掘，浸透とパイピング，土質基礎の破壊を含む，様々な破壊メカニズムが見られたのである．

現地調査ですぐに判明したことは，2005 年 11 月の上院国家安全保障・政府問題委員会に報告され, それと同時に ASCE と NSF の調査隊よる共同報告書としても発行されている．

専門的な調査

この数ヶ月間に，堤防の決壊を専門的に詳細を評価し，ハリケーン／洪水防止システム全体の現状を確かめるために，多くの調査が開始されている．その中で最大のものは関係機関合同性能照査タスクフォース IPET によるものであり，この組織は米国陸軍工兵隊 USACE によって組織され，産学官の様々な分野の専門家を結集させたものである．その一方で，NSF/カルフォルニア大学バークレー校の調査隊やルイジアナ調査隊によっても補足的な現地調査が行われているが，これらはルイジアナ州が後援し，ルイジアナ州立大学ハリケーンセンターの先導によって行われているものである．

これらの調査は，それぞれ色々な目標と目的をもって行われたが,「工学的な知識があれば，おびただしい数の被害やそれによる二次的な被害は防げたはず」と結論づけている．多くの弱点が明らかにされ，この災害から多くの教訓が得られた．ニューオーリンズや世界の他の発達した地域には際どいハリケーン対策を行っているところもあるが，この対策を見直す上で役立つだろう．

以上の調査の結果に対する技術的評価は現在行われており，それが終われば一般にも公開されるだろう．

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South Louisiana Comprehensive Coastal Protection and Restoration

Jeffrey A. Melby, PhD

Hurricanes Katrina and Rita devastated Southern Louisiana during the Fall of 2005. The high level of destruction was partially due to long term sediment supply constraints and related coastal erosion. Local constituencies demanded that the Federal, State, and local Governments take action in order to provide coastal protection for their communities. Immediately following Hurricane Rita, The United States Congress formally directed the U.S. Army Corps of Engineers, in partnership with the State of Louisiana, to develop a full range of flood control, coastal restoration, and hurricane protection measures for South Louisiana. This study, called the South Louisiana Comprehensive Coastal Protection and Restoration, or LACPR, included conceptual design of a levee system that would span the Louisiana coastline from the Louisiana-Texas border to Slidell. The levee system was in direct response to the congressional directive for a “comprehensive category 5 hurricane protection system”. The study was conducted and a preliminary report was drafted that is presently under review.

The study included developing a suite of Category-5 hurricanes. As part of this effort, a team of internationally renowned hurricane experts were assembled to define the criteria for developing the design storm suite. For preliminary design, a storm similar to Hurricane Camille in size, minimum central pressure, maximum wind speed, and forward speed was identified as being reasonable and representative of the “category 5” directive. The hurricane tracks were varied to follow tracks of historical hurricanes. Hurricane winds, wind-wave development, storm surge, and wave transformation numerical models were employed to determine surge and wave conditions along the 5 levee alignments. The maximum surge and coupled wave conditions and wave setup were applied along the coast using some engineering judgment in order to develop design conditions for the levee protection system.

Five levee alignments were selected from many alternatives. The differences between the alignments included planform location of the levee to provide varying strategies of protection. The minimal alignments left some communities without protection. Two of the levee alignments included large cutouts to provide open exposure for tidal wetlands.

A workshop was held in Vicksburg to define potential structural and foundation alternatives. Primary problems addressed included deep soft foundation materials and high-cost shallow-sloping levee cross sections. A number of very innovative structure cross section and foundation alternatives were proposed. Most of the alternatives will require significant engineering analysis that could not be completed for the preliminary design. Therefore, the preliminary analysis only included conventional trapezoidal earthen levees with varying armoring alternatives and simple foundation treatment, such as deep-soil mixing. The final design of the levee system will be summarized in this presentation.

南部ルイジアナの総合海岸防災と復興

米国陸軍工兵隊技術研究開発センター　Jeffrey A. Melby

2005 年の秋に，ハリケーンカトリーナとリタはルイジアナ州南部に被害をもたらした．その甚大な被害は，一つには長時間の強制的な土砂供給と海岸侵食によるものであった．各地域の人々は，連邦政府，州政府，地方の政府機関に対し，彼らの地域の海岸を守る施策の実行を求めた．ハリケーンリタの直後に，アメリカ合衆国議会は米国陸軍隊に対して公式に，ルイジアナ州と協力し，南部ルイジアナのできる限りの氾濫防止，海岸の復興，ハリケーン対策に努めるよう指示を出した．この調査は南部ルイジアナ総合海岸防災・復興 LACPR と呼ばれ，テキサス州との境界からスライデル市に至るルイジアナ州沿岸をまたぐ堤防システムの概略設計も含んでいる．この堤防システムは，議会の「カテゴリー5 のハリケーンに対する総合防災システム」に関する指示に応じたものである．この調査は終了し，暫定報告書が作成されて，その内容の吟味が行われているところである．

この調査ではカテゴリー5 のハリケーンの特性を明確にすることも行った．その一環として世界の著名なハリケーンの専門家による委員会が組織され，設計に用いるハリケーンの性質を明確にする基準を定めたのである．そして，概略設計では，ハリケーンカミールと同じ規模，最低気圧，最大風速，進行速度のハリケーンが，カテゴリー5 に対応する合理的で現実性のあるハリケーンとされた．ハリケーンのコースは，過去のハリケーンのコースの中から選んだ．そして，ハリケーンの風，風波の発達，高潮，浅海波浪変形に関する数値計算モデルを駆使して，堤防の 5 つの区間における高潮と波浪を推算した．こうして求めた各海岸における最大の高潮偏差，波浪諸元，ウェーブセットアップを，工学的な判断も踏まえながら，堤防システムの設計条件に定めた．

堤防の多くの区間から 5 つを選ぶことにした．これらの区間は場所によって防護の状況に違いがある．このうち最小の区間には，堤防の外側にもいくつかの集落がある．また，2 つの区間には，干潟から水が抜け出るための大きな切り欠き部がある．

ビックスバーグでは，実現可能な堤防の構造と地盤の候補を選定するために，ワークショップが行われた．そこで提起された最初の難問には，地盤が深いところまで軟弱な材質であることや，なだらかな傾斜堤の断面では建設費が高いということがあった．様々な革新的な構造断面や地盤の候補も提案されたが，そのほとんどは概略設計だけで詰めることのできない重要な工学的な検討が必要になると思われるものだった．したがって，概略的な検討においては，一般的な台形の盛土堤を対象とするものとし，被覆材は変えるが，地盤改良は深層混合処理のような簡単な工法を採用する場合に絞った．今回の講演では，その堤防システムの最終設計の概要を紹介したい．

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Panel Discussion

@Coordinator and Panelist

Coordinator: Dr. Shigeo Takahashi, PARI
Panelist： Mr. Naota Ikeda, MLIT
Professor T. Takayama, Kyoto U.
Professor M. Isobe, U. Tokyo
Professor Billy L. Edge, Texas A&M University
Professor Robert A. Dalrymple, Johns Hopkins University
Professor Peter G. Nicholson, University of Hawaii
Dr. Jeffrey A. Melby, U.S. Army Corps of Engineers

@ Theme of the Panel Discussion：

Future prevention of storm surge disasters； "Preparedness for the worst case."

Hurricane Katrina became the most destructive natural disaster in American history. Comprehensive surveys and reviews of the Hurricane Katrina disaster were made in the United States. One of the major lessons learned form the disaster is that we have to prepare for the worst case and that the scenarios for the worst case are essentially important to mitigate such devastating disaster.

The coastal areas in Japan have been attacked by typhoons and suffer from many storm surge disasters. The design system of the coastal defenses in Japan was developed and used after the Isewan Typhoon disaster in 1959, which is relatively simple based on the possible worst case as the design storm surge and the design storm wave. However a worse case than the worst case may happen. Especially, the current design level in Japan is not sufficient for the worst case.

In the panel discussion we like to discuss the coastal disaster prevention in the future focusing on "preparedness for the worst case." The worst case defined here is a worse case than the current design level by one rank, for example, with the return period of more than one thousand years. The worst case causes devastating results as the Hurricane Katrina Disaster including the failures of the coastal defenses. Although it may be almost impossible to prevent the disaster with structural countermeasures against such the worst case, we can mitigate it with non structural countermeasures considering the possible scenario of the worst case disaster.

The following subjects will be discussed to consider the preparedness for worst case.

1. What is the worst case?
2. Is the Katrina disaster the worst case?
3. How to prepare for the worst case?
4. Present situation in the U.S.
5. Present situation in Japan.
6. What is the problem for actual use of the worst case scenario?
7. What should be studied further?

パネル討議

@コーディネーターとパネリスト

コーディネーター：	港湾空港技術研究所	高橋重雄
パネリスト：	国土交通省	池田直太
	京都大学教授	高山知司
	東京大学教授	磯部雅彦
	テキサス A&M 大学教授	Billy L. Edge
	ジョンホプキンス大学教授	Robert A. Dalrymple
	ハワイ大学教授	Peter G. Nicholson
	米国陸軍工兵隊技術研究開発センター	Jeffrey A. Melby

@パネル討議のテーマ：　将来の沿岸防災：ワーストケースへの備え

ハリケーンカトリーナは米国の自然災害史上最悪であった．米国ではハリケーンカトリーナの災害について総合的な調査が行われている．この災害で学ぶべき重要なことの一つは，カトリーナの災害のようなワーストケースに備えることが不可欠であり，そうした非常に厳しい災害を防ぐには，こうしたワーストケースに対してその災害を具体的に想定したシナリオが必要であることである．

日本の沿岸域は毎年台風に襲われ，これまで多くの高潮･高波災害を経験している．日本の沿岸域の高潮防災施設の設計体系は，1959 年の伊勢湾台風以降整備され今日まで使われている．それは比較的簡潔なもので，ワーストケースの高潮や高波を想定しそれを設計高潮･高波として，それに対して防災施設の設計を行うものである．しかしながら，そのワーストケースより更に厳しいケースも起こりうる．特に日本の設計レベルはワーストケースとしては不十分なのかもしれない．

今回のパネル討議では，将来の沿岸防災を考えるため，「ワーストケースへの備え」について討議したい．ここでワーストケースというのは，現在の設計レベルより一段と厳しいもので，例えば再現期間が 1000 年程度のものを考えている．ワーストケースとは，ハリケーンカトリーナのような甚大な災害をもたらすケースであり，こうしたケースでは防災施設の被災とそれによる災害の拡大も考える必要がある．防災施設などハードによってこうしたワーストケースの災害を防ぐことはできないが，ワーストケースのシナリオ（ワーストケースの時の災害の具体的な状況を示すシナリオ）を考えることによって，ソフト的な対応が可能となり，災害を低減することができる．

パネル討議では，パネリストによって以下のテーマについて議論することにより，ワーストケースに備えることについて考える．

1．ワーストケースの定義は?
2．カトリーナはワーストケースであったか?
3．どのようにワーストケースに備えるのか?
4．米国の現状
5．日本の現状.
6．ワーストケースやワーストケースのシナリオの実用化の問題点
7．更に研究すべき課題

@Proceedings of the seminar (セミナーの講義集について)

The seminar proceedings will be released on the websites after the seminar.
(今回のセミナーの講義集を作成し，ホームページで公開する予定です．)

@Steering Committee of the seminar (セミナー実行委員会)

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