出國報告（出國類別：考察）

「赴日本消防研究中心之災害弱者火災避難安全技術研習」報告

服務機關：內政部建築研究所

姓名職稱：陳建忠組長

蘇鴻奇副研究員

派赴國家：日本

出國期間：99 年 8 月 30 日至 9 月 10 日

報告日期：99 年 12 月 07 日

摘　要

本計畫依據本(99)年度本所派員出國研習相關防火與避難技術。計畫目的主要前往日本消防研究中心、建築總合試驗所耐火防火實驗室，並研習「災害火災避難區劃技術」與「災害避難行動輔助設備」技術。

為提升本所安全防災研究廣度，鑒於日本對於都市地區洪泛減災技術具有前瞻與獨特技術，增加「都市地區洪泛減災技術研習」等行程，前往日本雨水貯流浸透技術協會、建設技術展示館、防災公園、大阪市水道局等單位，研習利用浸透工法，透過貯存與的減災轉換技術，將災害減至最低程度。

目次

壹、考察目的

本計畫依據本(99)年度本所派員出國計畫辦理。計畫目的主要前往日本消防研究中心、建築總合試驗所耐火防火實驗室，並研習以下技術：

1.災害火災避難區劃技術：瞭解日本對於火災現場避難區劃之技術（例如：等待救援空間設置或暫時避難空間）。

2.災害避難行動輔助設備：學習日本對於災害避難行動輔助設備之研發構想與技術。

為提升本所安全防災研究廣度，因全球暖化造成氣候變化劇烈，例如去（98）年莫拉克風災，鑒於日本對於都市地區洪泛減災技術具有前瞻與獨特技術，殊值派員研習，增加「都市地區洪泛減災技術研習」等行程，前往日本雨水貯流浸透技術協會、建設技術展示館、防災公園、大阪市水道局等單位，並研習以下技術：

1.應用浸透工法貯流減災技術：研習日本利用浸透工法於公共用地、住宅、道路用地，將雨洪水貯流之減災技術，以及浸透工法推廣實施作為。

2.參訪建設技術展示館：研習日本對於建築技術之展示應用作為，尤其是安全防災技術之推廣。

3.參訪防災公園：研習日本對於防災公園規劃及運作技術。

4.參訪大阪市地下雨水滯留隧道：研習大阪市克服都市地勢低窪的條件限制，設置大型地下雨水滯留隧道將地面逕流滲入地下，防止地層下陷解決排水問題的技術。

效益預估：

1.藉由本次研習可以蒐集與瞭解日本對於災害避難等場所之防火避難技術與國內之差別，以及研習相關防火實驗技術，除了作為國內未來改善與研究之借鏡外，更期望透過國際交流，強化精進與提升國內防火安全研究技術。

2.本次研習預計瞭解日本如何利用浸透工法於公園、學校、住宅、道路等用地，將原本可能造成淹水災害的大量雨洪水，透過貯存與的減災轉換技術，將災害減至最低並妥適運用，另外將研習日本對於該技術的推廣方式，以作為國內應用可行性之評估研究與參考。

貳、考察過程

一、參訪行程

活動日期：99 年 8 月 30 日（一）至 9 月 10 日（五）合計 12 天

日　期	活　動　內　容	備　考
8 月 30 日（一）	1.啟程、抵達東京	路程
8 月 31 日（二）～9 月 04 日（六）	2.參訪建設技術展示館（研習推廣安全防災技術）。 3.參訪防災公園：東京臨海廣域防災公園或堀切二丁目防災公園或其他防災公園等（防災公園規劃及運作技術研習觀摩）。 4.參訪雨水貯流浸透技術協會（利用浸透工法對雨洪水調節減災技術研習觀摩）。 5.參訪日本消防研究中心（災害火災避難區劃技術、避難設備研發構想與技術研習觀摩）。	東京
9 月 05 日（日）	6.由東京至大阪	路程
9 月 06 日（一）～9 月 09 日（四）	7.參訪日本建築總合試驗所耐火防火實驗室（日本防火材料與防火構造等相關先進實驗技術研習觀摩）。 8.參訪京都大學防災研究所 DPRI(地震災害應變、坡地災害與極端氣候預測及防災技術)。 9.參訪下水道科學展示館（大阪市下水道防災應用處理技術研習觀摩）。 10.參訪人與防災未來中心（防災避難規劃及運作技術研習觀摩）。	大阪、京都
9 月 10 日（五）	11.返程由大阪抵達台北	路程

二、日本消防研究中心、建築總合試驗所耐火防火實驗室考察研習

（一）日本消防研究中心

日本消防研究中心（Fire Research Institute）設立於 1948 年係隸屬於日本國家消防廳（National Fire Defense Agency），於 1961 年設立研究部門並於 1963 年研究部門擴展為火災研究部門與第二研究部門，1969 年再增設第三研究部門，2001 年改制為獨立行政法人消防研究所 NRIFD（National Research Institute of Fire And Disaster ）設置研究企劃部、基礎研究部門、專案計畫研究部門。2006 年獨立行政法人消防研究所 NRIFD 再改制為隸屬於日本總務省消防廳消防大學之消防研究中心，並設置火災災害調查部門、技術研究部門與研究企劃部門。

目前的研究範圍包含有：

1.過密都市間的火災安全確保

2.化學物質火災與爆炸之預防與滅火

3.地震與材質老化對石油儲槽之保護

4.大規模自然災害發生之火災與災害防止對策

5.特殊災害防止

6.災害與意外事故之洩漏與危險物質調查

本次參訪由日本消防研究中心的松島早苗主任研究官接待，並特別針對都市公共區域火災進行簡報，包含地下鐵火災、歌舞伎町的擁擠居住型態火災、神戶市倉庫火災、都市火災旋風現象、店鋪火災等議題。日本的火災研究始於二次大戰之後，因都市大規模的木造建築容易引發火災，1970 年以後日本火災的型態開始增加不同的類型，例如油槽火災。1990 年以後商場與醫院類型的火災增加，近 20 來隨著防火研究的進步已較少發生重大的火災案例。

日本對於災害避難行動輔助設備之研發構想與技術也有實際之研發應成果。當火場有避難弱勢之人員例如行動不良或受傷者無法順利自行逃脫困境，日本對於避難弱者研發了智慧化行動輔助設備，採用小型履帶式智慧化自走機器人（如圖 11、12），當救難人員進入災害現場時機器人跟隨進入並記憶路徑，發現避難弱者時再結合數台機器人將傷者運出。另有利用遙控機器人進行危險場所偵測任務（如圖 10）。智慧化自走機器人技術可引進或將資訊提供廠商研發以精進國內避難設備之功能。

日本近年也對於地震造成的火災進行研究，在地震之後有關火災避難與防災系統的議題如何規劃，例如除防災考量如何告訴居民災後要做什麼事情，如何引導居進行下一步動作。所以對於防災與避難議題充分與松島研究官交換意見，日本在地震火災後的避難考量可供我國火災避難議題的思考。

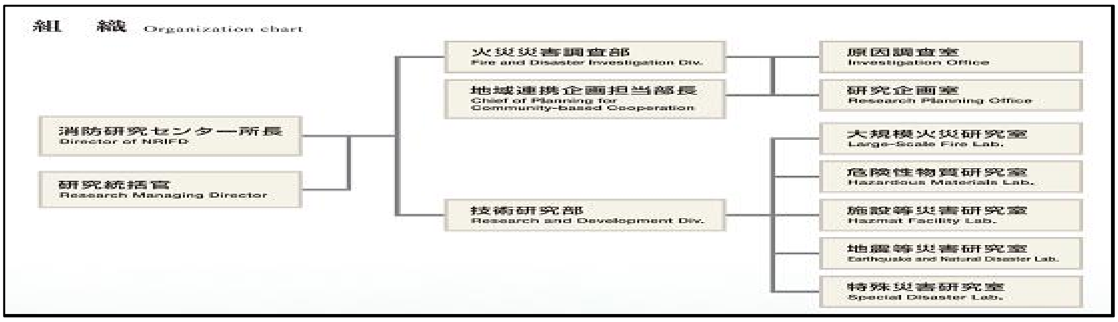


圖 1　日本消防研究中心組織圖

圖 2　日本消防研究中心全區配置圖

圖 3　參訪人員與松島早苗主任研究官合影

圖 4　日本消防研究中心本館外觀

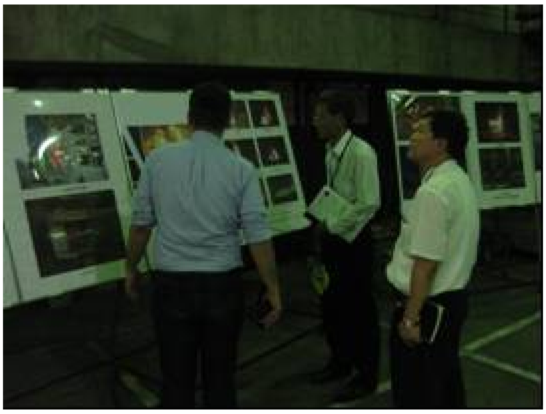


圖 5　松島研究官簡報

圖 6　撒水頭試驗裝置

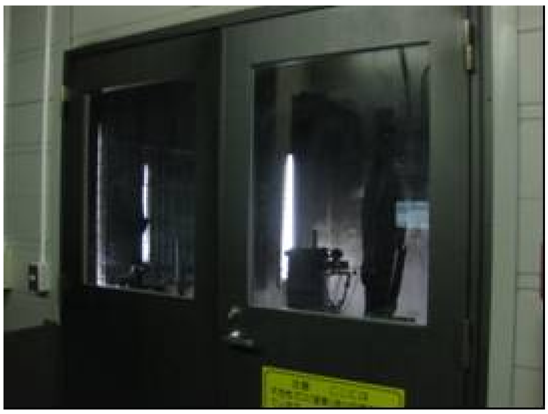


圖 7　防火綜合試驗場

圖 8　防火衣試驗裝置

圖 9　攜帶式低壓水霧滅火裝置

圖 10　火災現場遙控偵測設備

圖 11 小型履帶式智慧化自走機器人

圖 12 小型履帶式智慧化自走機器人
－操作範例

圖 13　過密都市空間火災研究

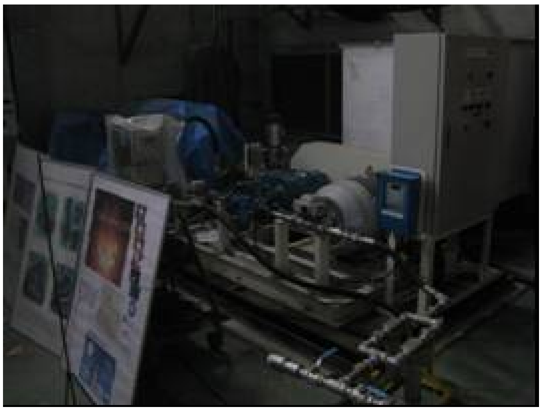


圖 14　高壓水泵

（二）日本建築總合試驗所耐火防火實驗室

財團法人日本建築總合試驗所是於 1964 年由國土交通省‧經濟產業省所共同管理的社會法人組織。試驗所著重於建築的性能試驗、評估與研究開發事項，以提升建築品質與安全性，增進國民生活品質。

營運方針計有四項：

1.本著公益法人的良知堅持，確保事業組織的透明性。

2.作為第三者機關的公平性，本於中立的立場進行試驗與評估事務。

3. 致力於最新的技術和知識的掌握，以符合顧客以及社會的需要。

4. 試驗與評估事務之運營業務合於國際規範之要求。

組織概要說明：

1.試驗研究中心(105 名)

2.產品認証中心(12 名)

3.建築評定中心(31 名)

4.構造評定中心(19 名)

5.事務局(19 名)

總計 191 名

設施概要說明：

1.建築總合試驗所本部組織：

(1) 建築總合試驗所本館

(2) 耐火實驗棟

(3) 音響‧熱實驗棟

(4) 風洞實驗棟

(5) 新館

2.本部以外組織：

大淀試験室・堺試驗室・京都試驗室・加古川試驗室・神戸各試驗室

大阪事務所・東京事務所

日本建築總合試驗所的參訪由「耐火・防火試驗室」田坂茂樹室長接待，並介紹建築總合試驗所本部的實驗棟，包含耐火實驗棟、音響・熱實驗棟、 風洞實驗棟、結構實驗棟等。建築總合試驗所除一般委託檢測與儀器校正之外，也接受建築物的調查與診斷事項，同時也基日本建築基準法由國土交通大臣所認可之「指定性能評定機關」，並且也是符合住宅品質促進等相關法律之「登錄試驗機關」與「登錄住宅型式性能認定關」。

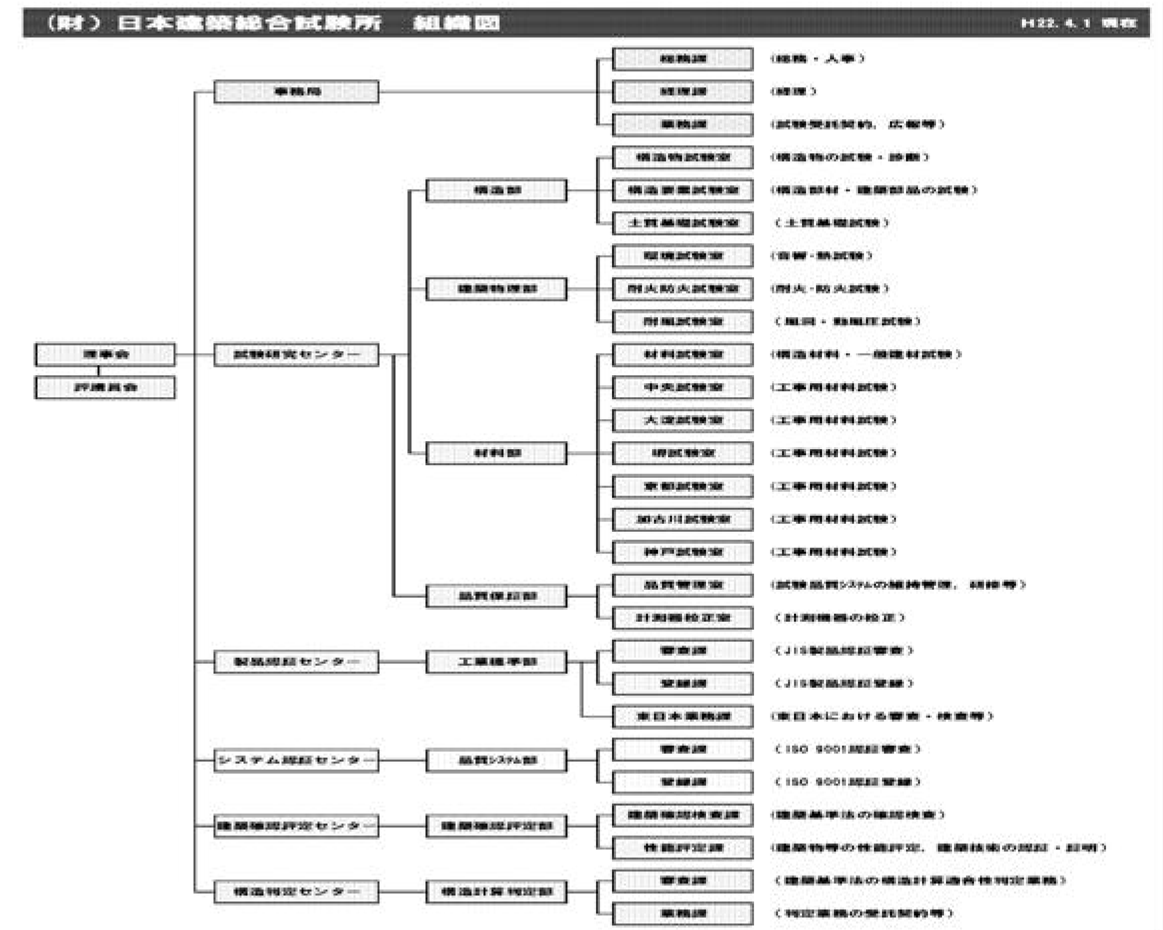


圖 15　建築總合試驗所組織圖

圖 16　建築總合試驗所

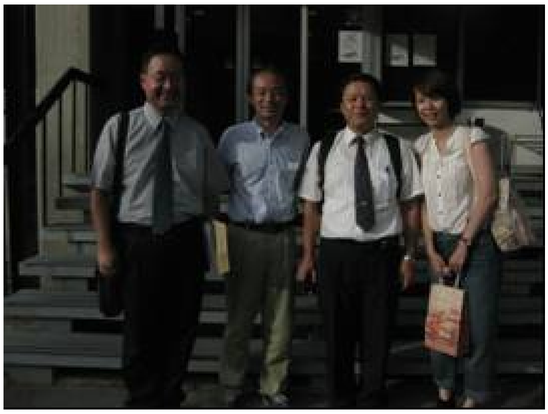


圖 17　與田坂茂樹室長合影

圖 18　建築總合試驗所—圓錐量熱儀

圖 19　建築總合試驗所—水平板式構件加熱爐

圖 20　木構材炭化率試驗樣品

圖 21　建築總合試驗所—柱加載實驗裝置

圖 22　建築總合試驗所—大型萬能試驗機

圖 23　建築總合試驗所—樓板衝擊音實驗裝置

圖 24　建築總合試驗所—高頻樓板衝擊音實驗裝置

圖 25　建築總合試驗所—風洞實驗裝置

有關日本防火檢測技術的發展在撒水幕的檢測實驗的技術方面，係採用加熱爐提供熱源進行測試，較我國目前撒水幕的檢測實驗使用木材框架為熱源，在溫度與壓力控制比較皆較為客觀。建築總合試驗所提供日本在撒水幕檢測的研究成果與水系統結合耐火構件耐檢測實驗的研究成果供此行考察研習參考。

三、日本雨水貯流浸透技術協會、建設技術展示館、防災公園、大阪市水道局等單位考察研習

（一）日本雨水貯留滲透技術協會

氣候變遷因應全球氣候變化劇烈，日本在都市地區洪泛減災技術具有前瞻與獨特技術，殊值派員研習。本計劃於東京地區「都市地區洪泛減災技術研習」是由日本雨水貯留滲透技術協會忌部正博常務理事接待，並安排參訪「鶴見川多目的遊水地」與「妙正寺川洪泛調節池設施」，介紹東京地區的洪泛減災技術與設施。

鶴見川流域目前由日本國土交通省關東地方整備局京濱河川事務所流域調整課負責管理，此行參訪由該課二見拓也先生負責接待並進行簡報，介紹「鶴見川多目的遊水地」相關防災技術與設施。鶴見川位於神奈川縣，流經町田市、橫濱市青葉區、綠區、都築區、港北區、鶴見區、川崎市幸區河流長度 42.5 公里、流域面積 235 平方公里，鶴見川的流域區域時常出現水災。1980 年為減少洪患與確保河川整體機能而進行「總合治水對策」，河川整治對象包含流域、河川與下水道，工作計畫事項包含綠地恢復、滯洪區設置、多目的遊水地、下水道雨水貯留管道與建築物高架化等。2003 年完成啟用「鶴見川多目的遊水地」，由提防包圍遊水地區域，區域範圍內設置公園、運動場、體育館、道路與停車場等公共設施。

日本為加強都市水患的治理，於 1977 年開始針對都市內河川進行整治並涵蓋調整池、雨水貯留以及浸透等設施，例如東京的妙正寺川，為防範水患氾濫再沿河川流域範圍即設置許多調整池，於河水暴漲時可以有緩衝空間疏解暴增的水量，而且在平時這些調整池可以利用作為休憩廣場、公園綠地等多用途使用。例如本次參訪的妙正寺川第一調整池及附屬於集合住宅之範圍，經由外觀可以很明顯的看出建築物的居住使用範圍則抬高而底層低窪處處理成休憩庭園，兼具防洪安全與休憩運動功能。

圖 26　與忌部正博常務理事於「鶴見川流域中心」合影

圖 27　二見拓也先生簡報「鶴見川多目的遊水地」

圖 28　鶴見川防災設施配置圖

圖 29　鶴見川流域之公共足球場

圖 30　鶴見川流域

圖 31　「鶴見川流域中心」之大廳地圖

圖 32　妙正寺川第二調節池解說牌

圖 33　妙正寺川第二調節池溢水孔

圖 34　妙正寺川第一調節池內部區域

圖 35　妙正寺川第一調節池溢水孔

圖 36　妙正寺川第一調節池

圖 37　妙正寺川第二調節池

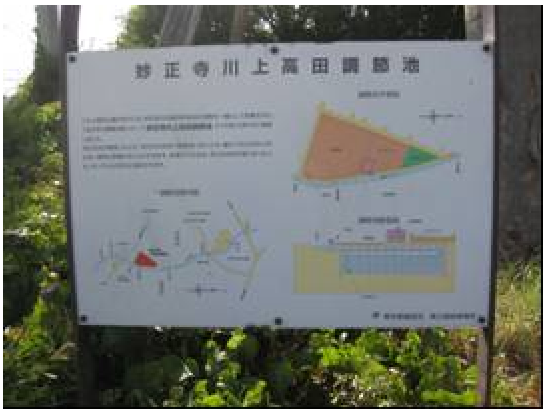


圖 38　妙正寺川上高田調節池解說牌

圖 39　妙正寺川上高田調節池

圖 40　妙正寺川

圖 41　妙正寺川沿岸調節池

圖 42　妙正寺川沿岸調節池公園解說牌

圖 43　妙正寺川沿岸調節池公園

（二）參訪建設技術展示館

建設技術展示館係隸屬於日本國土交通省關東地方整備局關東技術事務所，建設技術展示館的主要宗旨為介紹日本最新的建設技術，展示最新建設技術在公共建設方面節省成本與增加安全保障，以及有助於環境保護等新的建設技術。在建設技術展示館中展示介紹分為室內展示場與室外展示場二部份，展示概要分述如下：

1.室內展示場：新技術展示區、歷史展示區、關東地區整備局的事業介紹展示區、NETIS 寬頻無線晶片技術展示區、接觸互動展示區。

2.室外展示場：模型的展示實物包含介紹 46 種道路鋪路技術的實物展示介紹、 落水管與共同溝的施工過程的展示等。

圖 44　建設技術展示館全區配置圖

圖 45　室內展示場平面圖

圖 46　室內展示場平面外觀

圖 47　展示看板

圖 48　新技術展示區

圖 49　共同管溝實物的展示

圖 50　東京防災體系架構　　圖 51　都市高空鳥瞰正攝系統

圖 52　超輕型高功率抽水馬達　　圖 53　坡地植生抑制技術

圖 54　免工具假設工程技術實物展示　　圖 55　道路鋪路技術實物展示

（三）東京臨海廣域防災公園

來自於阪神淡路大地震的經驗，為預防首都東京發生大地震災害如何匯整由全國各地的救災隊伍及資源，及有效整合調度及指揮並建立對災害的應變處理據點。所以日本在東京灣的海埔新生地上規劃並建立一個具整備與水上聯合運輸功能的防災據點。

「東京臨海廣域防災公園」是東京都圈的防災司令部，也是賑災時之支援部隊等的大本營及支援災害醫療工作的基地。此防災公園內設有「災害現場對策本部」等機構，可以在發生東京都都直下型地震等大規模災害時，彙整現場的受災情況調整就災的對策。防災公園分為二部份，國營公園佔地面積為 6.7 公頃，東京都立公園佔地面積為 6.5 公頃，總面積達 13.2 公頃。在管理方面，為了提高公園平時的利用率，由國土交通省和東京都來共同分擔其規劃建設工作。規劃建設設定為以下三方面的定位來進行：

1.在平時係為防災準備的場所。

2.提供提供各種防災體驗、學習、訓練場所，以增長一般民眾對於防災的知識與技術，並培養自助及互助意識。

3.利用臨海副都心的區位特色，創造的一個兼具都市休憩的場所。

「東京臨海廣域防災公園」的本棟建築物於東京發生地震等大規模災害時是整合調度及指揮應變的中心，在平時則肩負教育與宣導功能。教育與宣導所展示的內容包含：災害情境體驗、靜態的宣導看板、救災物資的實物展示、動畫影片播放等，其中給於參訪者印象深的是災害情境體驗—「東京直下型地震 72 小時體驗」，利用實際情境讓參訪者可以真的體會震災後的情形，並利用手持式問答操作小型電腦來考驗參訪者對模擬情境的反應，以提供受災時最正確的反應動作與觀念，教育效果非常好可供我國進行防災教育參考。

圖 56　東京臨海廣域防災公園平面配置圖

圖 56　東京臨海廣域防災公園本部大樓外觀

圖 57　東京臨海廣域防災公園本部大樓大廳

圖 58　防災公園解說牌

圖 59　防災公園救災物品倉庫

圖 60　防災設施解說牌

圖 61　可外搭帳篷之涼亭

圖 62　多功能炊事椅

圖 63　緊急電源

圖 64　多功能廣場

圖 65　衛生設施

圖 66　多功能飲水機

圖 67 癌研有明醫院緊鄰防災公園

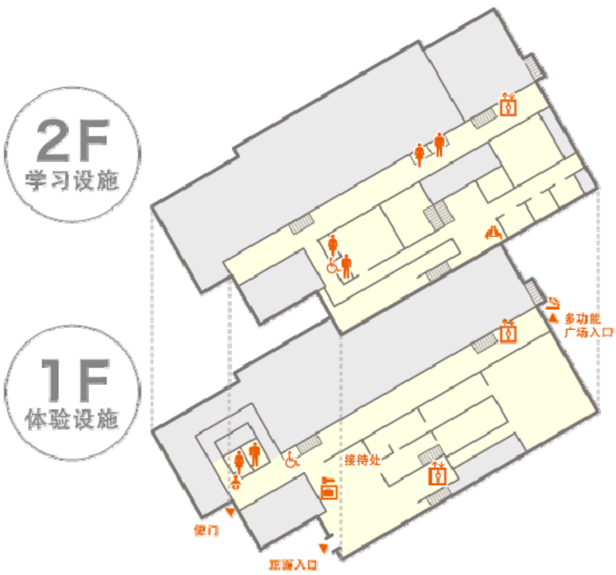


圖 68　東京臨海廣域防災公園本部大樓—東京直下型地震 72 小時體驗位置圖

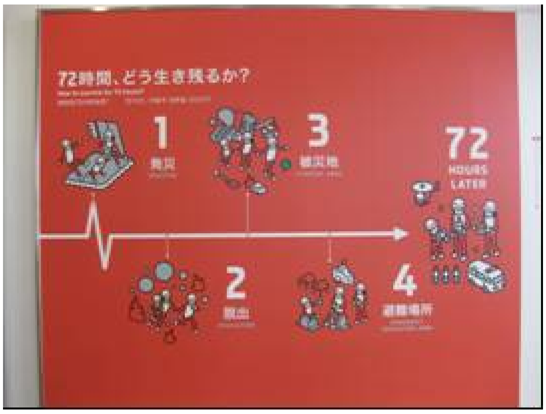


圖 69　東京直下型地震 72 小時體驗—

解說牌

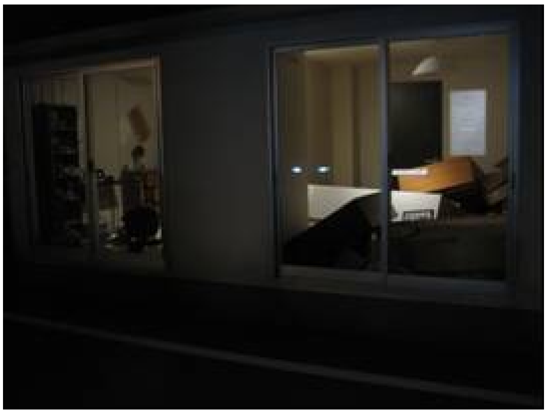


圖 70　東京直下型地震 72 小時體驗—

體驗屋

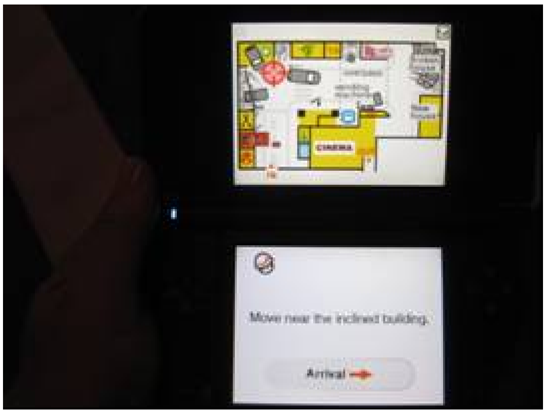


圖 71　東京直下型地震 72 小時體驗—

手持式問答操作小型電腦

圖 72　東京直下型地震 72 小時體驗—

宣導看板

圖 73　東京直下型地震 72 小時體驗—

救災物品介紹（一）

圖 74　東京直下型地震 72 小時體驗—

求生物品介紹（二）

（四）堀切二丁目防災公園

防災活動據點「堀切二丁目防災公園」位於東京都葛飾區，於 1999 年 4 月完成併的開始營運。這個防災公園是由鄰近的四個防災民間組織所籌設，從討論設立基本概念開始，到公園內防災機能的確立，到防災公園完成後並設立「堀切二丁目公園管理運營委員會」負責公園營運與自主管理。

堀切二丁目防災公園的內容特點如下：

1.在平時營運時

無論平常或者災害來臨時公園的最大受益者都是鄰近的居民，所以公園的使用是以鄰近居民為主要考量。另外公園平常的主要使用者是兒童，所以營運委員會的組織成員有會有青少年委員會與兒童活動相關組織人員參加。

2.當發生災害初期時

當發生災害初期時防災公園可提供作為初期滅火所使用的 D 級幫浦和消防用水槽（40 噸），雨水貯留槽(20 噸)，另外公園還配置有防止火災延燒功能的設備。

3.災害發生後的生活維持

提供受災戶生活的支持保障，例如自來水供應缺乏時衛生器具的運作可以利用雨水貯留槽的設計考量，或設置提供臨時住宅用電的發電機。

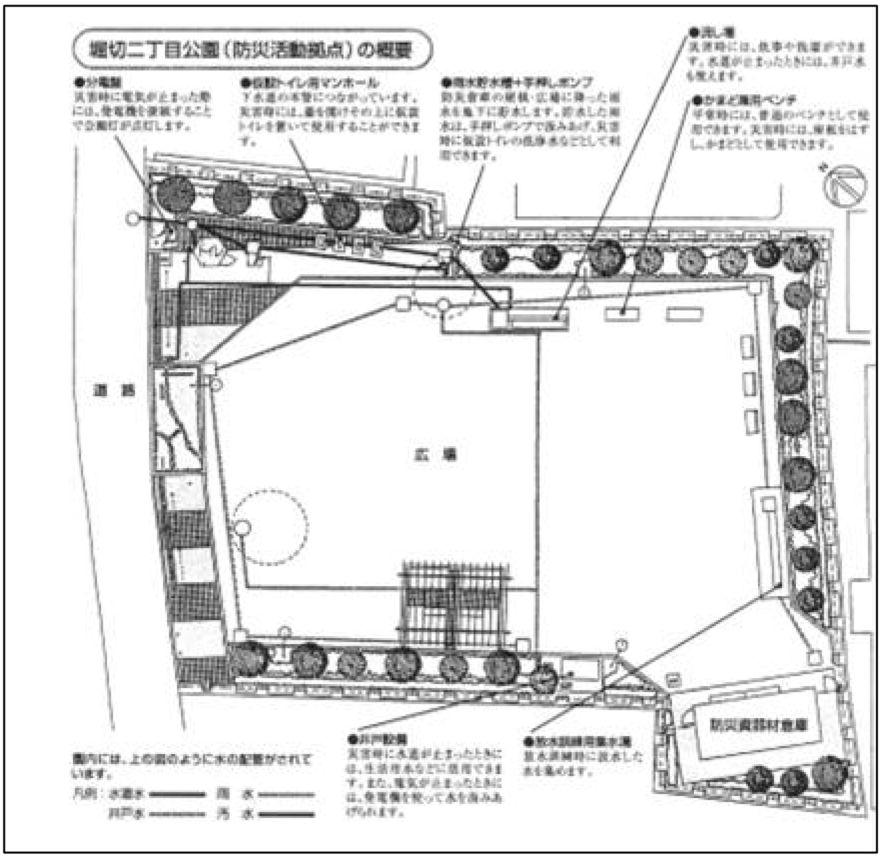


圖 75　堀切二丁目防災公園配置圖

圖 76　堀切二丁目防災公園指示牌

圖 77　堀切二丁目防災公園

圖 78　堀切二丁目防災公園—多功能飲水機

圖 79　堀切二丁目防災公園—雨水儲槽出水口

圖 80　堀切二丁目防災公園—多功能作業台

圖 81　堀切二丁目防災公園—消防水池指示牌

圖 82　堀切二丁目防災公園—防災倉庫

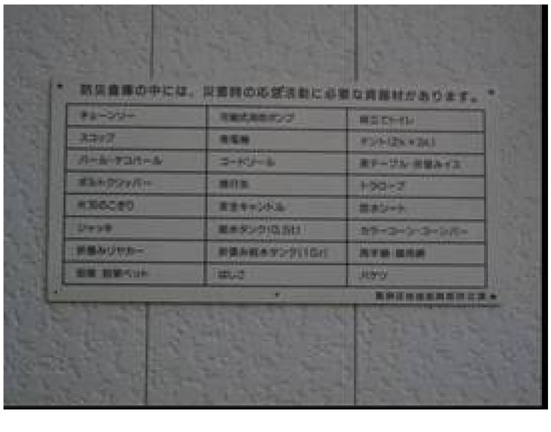


圖 83　堀切二丁目防災公園—防災倉庫物資告示牌

（五）京都大學防災研究所 DPRI

京都大學防災研究所 DPRI(Disaster Prevention Research Institute)設立於 1951 年隸屬於日本東京大學，設立宗旨主要為自然災害研究。該所共設置包含「災害理工學的基礎基礎研究部門」、「水災防治研究部門」與「地震及風災研究部門」等三個研究部門。由於 1996 日本阪神•淡路大地震所帶來的巨大災害，顯示出社會組織系統對於風險管理與災害減緩的缺乏，但是當時京都大學防災研究並沒已針對上述議題之研究部門。由於阪神•淡路大地震之經驗與社會對於自然災害研究需求的增加，故於 1996 年進行組織調整，共設置 5 個研究部門與 6 個研究中心如下所示。

京都大學防災研究所 DPRI 研究部門

1.社會防災研究部門

2.地震災害研究部門

3.地震防災研究部門

4.地盤災害研究部門

5.氣象水災研究部門

京都大學防災研究所 DPRI 研究中心

1.附屬巨大災害研究中心

2.附屬地震預測研究中心

3.附屬火山活動研究中心

4.附屬山坡地災害研究中心

5.附屬流域災害研究中心

6.附屬水資源環境研究中心

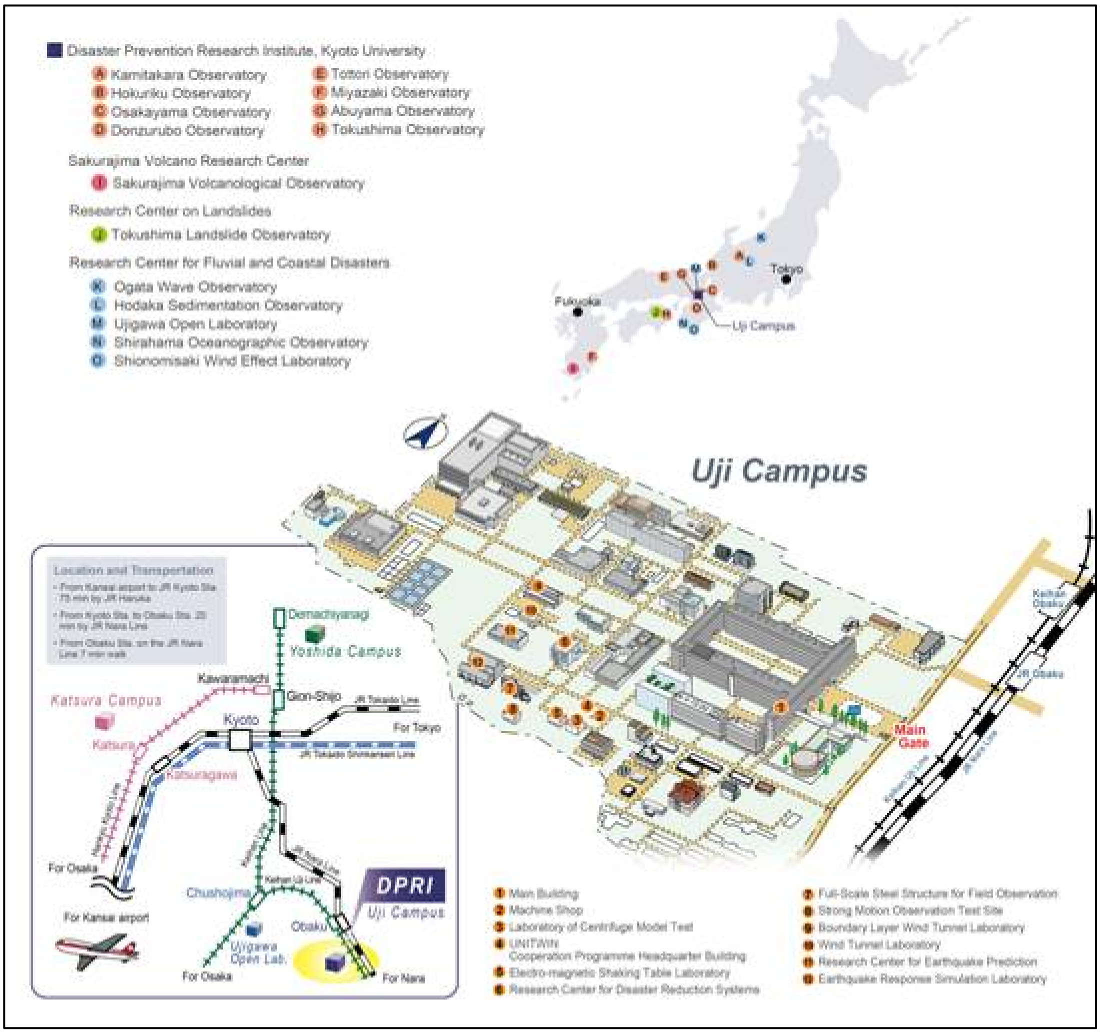


圖 84　京都大學防災研究所校區配置圖

圖 85　京都大學宇治校區

圖 86　田中哮義教授會談

（六）人與未來防災中心

人與未來防災中心主要是紀念發生於 1995 年 1 月 17 日的「阪神 • 淡路大地震」。此地震發生在日本兵庫縣的南部臨海地區，地震規模 7.3，最大震度 7，死亡與失蹤人數達 6,437 人，財產損失高達 89,268 億日圓，是日本近 80 年所造成傷亡最嚴重的地震。

人與未來防災中心的主要功能有 6 項：

1.展示：以通俗易懂的方式展示阪神 • 淡路大地震的經驗與教訓。特別是過對兒童進行有效的信息傳播，以講述防災的重要性、生命的可貴與共同生活的美好意義。

2.資料收集、保存：為了不使人們對阪神 • 淡路大地震的記憶隨著時間的流逝而消失，以便將受災者的感受與與地震的教訓傳之於後世，防災中心將收集與累積的資料整理成淺易懂的形式傳達給市民。

3.災害對策與專業人員的培養：大地震經驗的收集與最新的研究成果，通過系統性的提供有關防災的知識與技術，以培養地區防災人員與災害對策及實務的人才。

4.實踐性的防災研究與年輕防災專家的培養：以大地震經驗的累積與學術性的研究成果為基礎，進行有助於政府與地方制定防災政策。

5.應對災害的現場支援：大規模災害發生時，因應當地政府需求向受災地區派遣具有防災經驗豐富與執行實務的專家，並進行處置建議等等。

6.交流與網路：防災人員、研究人員、市民與企業等多種網路的形成，以成為國內外合作的中心，並促進及提高社會防災的能力。

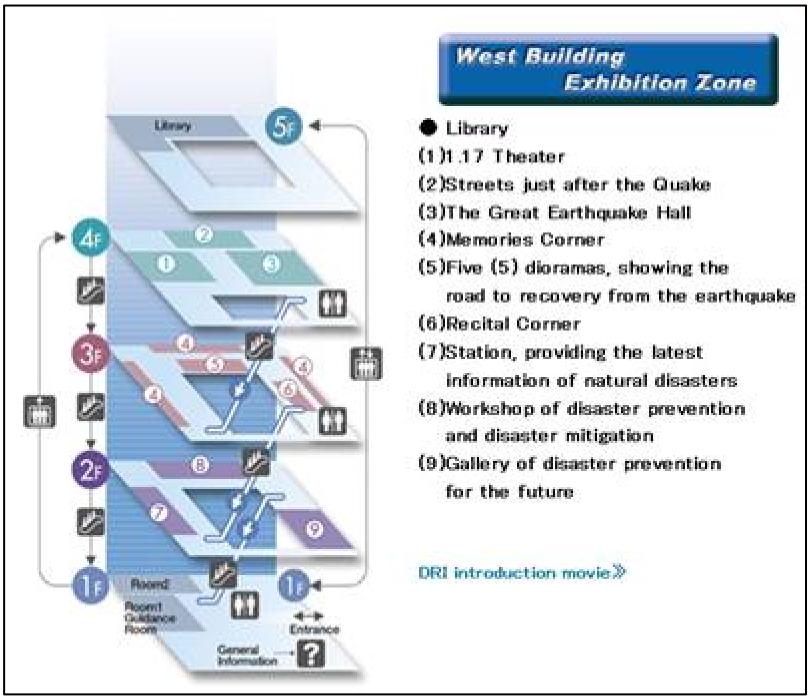


圖 87　人與未來防災中心西棟空間配置圖

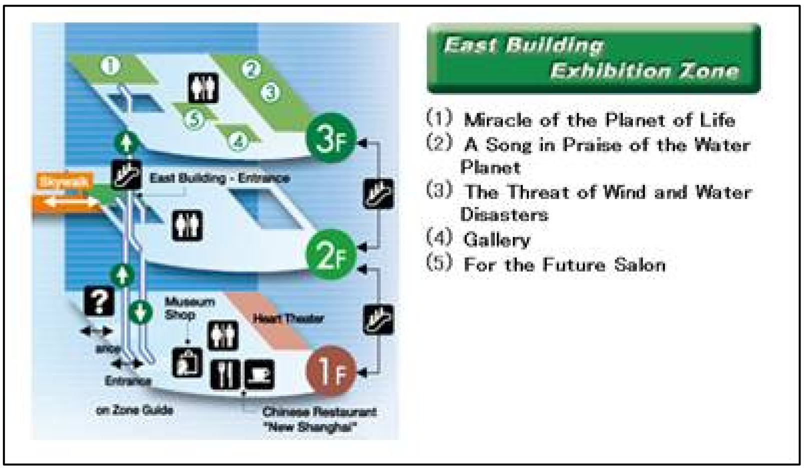


圖 88　人與未來防災中心東棟空間配置圖

圖 89　人與未來防災中心西棟建築外觀

圖 90　人與未來防災中心東棟建築外觀

圖 91　人與未來防災中心中庭景觀

圖 92　人與未來防災中心紀念碑

（七）下水道科學展示館

現代都市化急速發展，河川流域內保水、儲水能力降低，氣候變遷雨水量大增，常造成超出各抽水站排水量之降雨逕流量，而產生都市內大規模的積水現象。下水道除了肩負一般日常家庭與工業廢水排放與處理功能之外，另一項重要功能即是排放暴雨所造成之雨水排放以保護都市免於水患之威脅。

大阪市的下水道接管率已高達100％，日本在下水道工程除了實際執行面的確實要求，在教育宣導方面亦不遺餘力值得我國學習，大阪市於 1995 年設立「下水道科學館」來記錄大阪現代化下水道系統的百年紀錄，同時介紹大阪市的下水道建設成果與推廣下水道之相關教育觀念。「下水道科學館」為地下一層及地上六層之建築物，藉由不同樓層之展示主題來提供市民瞭解下水道系統的各項功能。各樓層相關主題如下所述：

1.地下一樓—「地下探險」：包含有劇場型態介紹下水道發展的歷史介紹，乘坐「地下探險號」到地底世界遨遊等。

2.一樓「大廳、水資訊角落」：接待中心、相關水資訊查詢區。

3.二樓「辦公行政區」：辦公行政區。

4.三樓「都市環境與污水系統」：都市下水道縮尺模型實體展示、水環境圖書館。

5.四樓「大阪的下水道系統」：污水處理程序、下水道的維持管理、豪雨體驗設施、合流式下水道系統改善介紹等。

6.五樓「水的奇觀」：對流、表面張力與水壓手動操作設施、水循環立體展示櫃。

7.六樓「水與生活」：利用溫室與水耕技術來栽培植物與養殖魚類，來展示放流水可以應用於生活的關係。

圖 93　下水道科學展示館外觀

圖 94　水循環立體展示櫃

圖 95　利用放流水進行水耕栽培植物

圖 96　對流手動操作設施

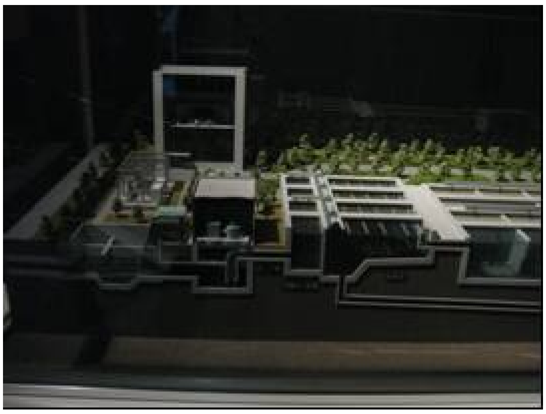


圖 97　都市下水道縮尺模型

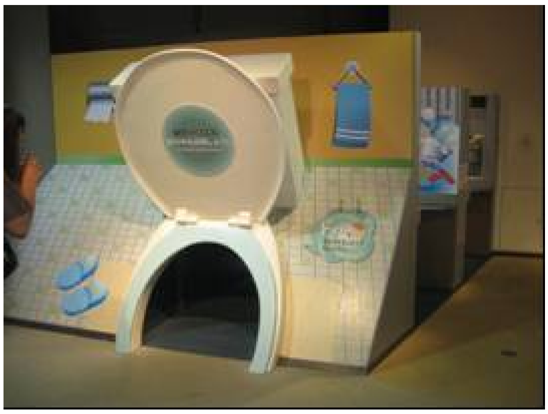


圖 98　污水處理程序體驗設施

參、考察心得

本次參訪與研習的過程中對於日本火災安全避難研究的現況與都市水患的防止措施，有深刻的印象，許多值得我國學習與借鏡之處。以下即就參訪與研習重要之心得分述如下：

一、有關日本火災安全避難研究因當地都市大規模的木造建築特點容易引發火災，所以早於二次大戰之後即開始進行。隨著都市型態發展的複雜化火災的類型也增加許都不同的型態，例如油槽火災、商場與醫院類型的火災等。但防火的法規與觀念也逐步更新，所以日本近 20 來已較少發生重大的火災案例。部分研究重心已開始思考地震造成的火災進行研究，以及在地震之後有關火災避難與防災系統的議題如何規劃等議題。

二、日本消防研究中心的發展過程，係由公部門設立再改制獨立行政法人，目前已再併入公部門。其過程顯示有關防災避難的研究機構因負有配合政策研發的任務需求，所以防災研究機構性質上較不適發展為獨立法人機構。

三、日本防災安全避難教育廣非常用心，例如「東京臨海廣域防災公園」的本棟建築物於東京發生地震等大規模災害時是整合調度及指揮應變的中心，在平時則肩負教育與宣導功能。其中災害情境體驗—「東京直下型地震 72 小時體驗」，提供參訪者受災時最正確的反應動作與觀念，教育效果非常好可供我國進行防災教育參考。

四、日本都市水患的治理的經驗，並非將都市的雨水改快的排出，排出的速度越快是必增加河川的負擔，而且必須增加堤防的高度，所以只要將雨水蓄留，避過降雨高峰期，再逐步將蓄留的雨水排出，則可減輕河川的排水負擔，減少都市水患，另外雨水蓄留池也可提供附近居民多用途使用的休憩運動功能。

五、日本對於防災的觀念非常的全面化與全民化，公園除遊憩與運動功能之外常兼具，防災的作用，例如小小的「堀切二丁目防災公園」平時就是小朋友的遊戲場所，災時則可提供附近居民避難的協助，在公園當中設置有避難設施並皆可運作，顯示平常有確實保養維護，以及居民的防災意識高。

肆、建議事項

一、都市防災策略的研究

日本近年積極對於高密度都市的火災（例如地鐵火災、大規模震災產生的火災等）避難進行研究，台灣的都市人口與建築物也是朝著高密度都市發展，此趨勢所延生防火與避難的議題我國亦有可能面臨。都市淹水防範研究之議題可參酌日本將雨水蓄留，避過降雨高峰期，再逐步將蓄留的雨水排出，減輕河川排水負擔的觀念。另外在執行面若能配合建管與土地政策的修改，例如土地開發配合獎勵措施以留設或提供部分土地為防災之用，或採取繳納代金措施以統一建設都市蓄洪設施，應可逐步減輕都市的水患威脅。所以高密度都市的火災的議題與都市雨水蓄留減輕河川排水負擔的觀念亦可提供國內對於都市防災研究之參考。

二、防火檢測技術的開發

有關日本防火檢測技術的發展在撒水幕的檢測實驗技術方面，係採用加熱爐提供熱源進行測試，較我國目前撒水幕的檢測實驗使用木材框架為熱源，在溫度與壓力控制比較皆較為客觀；另外日本在水系統結合耐火構件耐檢測實驗亦有許多研究成果。未來國內撒水幕的檢測與水系統結合耐火構件耐檢測方法建議可參酌改進。

三、防災安全教育的推廣

日本防災安全避難教育廣非常用心，例如災害情境體驗—「東京直下型地震 72 小時體驗」，提供參訪者受災時最正確的反應動作與觀念，教育效果非常好可供我國進行防災教育參考。宣導影片的製作也非常用心的採用小朋友喜歡的動畫形式，動畫影片中並融入災害來臨時居民所需作的正確反應動作，宣導效果非常良好，深值我國的防災教育宣導參考。

伍、附錄

一、日本消防研究中心－最新研究主題

研究紹介
Research

過密都市空間における火災

Ensuring safety against fires in overcrowded urban areas

ニューヨークWTCの超高層ビルへのテロ攻撃、韓国テグ市の地下鉄放火火災など、近年、過密都市空間において、過去に経験したことのない規模や種類の火災が発生しています。このような災害において、消火・救助・避難を強力に支援できるよう、わたしたちは地下施設などにおける火災の拡大や煙の流動、温度上昇などを予測する研究や、消防隊員が安全かつ効果的に消防活動を行えるよう、「ナノテク」を用いた消防用防火服の研究を行っています。また、首都直下地震などでは、阪神・淡路大震災のような大規模な市街地火災が危惧されており、このような場合に発生のおそれがある「火災旋風」という現象の解明にも力を注いでいます。

In recent years, there have been numerous disasters on a scale and of a variety never experienced before, including the terrorist attack on the World Trade Center in New York City and the subway arson fire in Daegu, Korea. We are conducting research on predicting the development of fire, spread of smoke and the concentration of toxic gas in underground facilities on fire in an attempt to strongly support firefighting, rescue and evacuation efforts. Research is also being carried out on protective clothing for firefighters that utilizes nanotechnology to improve the safety of fire fighters and their ability to perform firefighting activities. In addition, effort is being put into elucidating the phenomena of fire whirls, which can occur during widespread urban fire such as the Great Hanshin Earthquake disaster.

消防活動が困難な屋内空間における、火災・煙・有毒ガスのシミュレーション。

Fire, smoke, and toxic gas simulations in special indoor spaces where firefighting is difficult

2003年 韓国テグ市の地下鉄放火火災
(写真提供:聯合=共同)
2003 subway fire in Daegu, Korea
(Photo: Rengo, Kyodo)

バーチャルリアリティ技術を使った火災の擬似体験室
Fire simulator using virtual reality technology

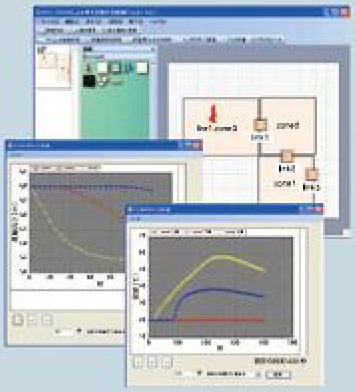
地下鉄駅舎構内のような地下施設や超高層ビルは、空間・空調・排煙系統が複雑に接続されたネットワーク構造になっています。火災発生時の火災の進展や煙の拡散は、このネットワークのつながり方次第で著しく異なります。2003年に韓国テグ市で発生した地下鉄放火火災では死者192人のうち、約50人の方が地下施設内で逃げ遅れて亡くなりました。

これまでにわたしたちは、火災時の効果的な避難誘導方法の検討や人間行動の解明を進める目的で、「火災体験シミュレータ」を開発しました。このシミュレータには、実災害を擬似体験できるバーチャルリアリティ技術が使われています。このシミュレータにより、テグ市の地下鉄火災や、2001年に発生した新宿雑居ビル火災をシミュレートしました。

現在は、さらに、地下施設・超高層ビルのCADデータなどのデジタル設計データを使って、そのなかで発生する火災の進展状況や、温度・煙・有毒ガスなどの変化を予測することができる「3次元熱流体火災シミュレータ」の開発を進めています。このシミュレータは、火災予防対策や消防戦術などの立案、消防隊員の教育訓練等に利用できます。

Subway facilities, such as those in subway station complexes, and skyscrapers have a network-like structure of intricately connected spaces and HVAC systems. The spread of smoke and development of a fire in such structures markedly varies depending on how such connections are networked together. Out of the 192 fatalities in the 2003 Daegu subway fire, about 50 passengers could not escape fast enough from the subway complex.

■平易な入出力で火災進展を予測できる二層ゾーンプログラム
Two-layer zone model with user-friendly graphical interface used to estimate fire/smoke spread



We have developed a "fire experience simulator" to study effective evacuation guidance methods and shed light on human behavior during fires. The simulator employs virtual reality technology that allows people to experience a realistic simulation of an actual disaster. Using this simulator, we have already simulated the Daegu subway fire as well as the multiple tenant building fire that occurred at Shinjuku in 2001.

At present, we are developing a CFD fire simulator by utilizing digital design data, including CAD data of subway facilities and skyscrapers to predict the development of a fire in such structures and the resulting variations in temperature, smoke density, and toxic gases, among other things. This simulator can be used in the planning of fire prevention measures and firefighting strategies, as well as in the education and training of firefighters.

に対する安全確保

燃焼実験データベースの構築。

Creation of a flammability test database

火災の進展を予測するシミュレータが実際の火災を精度よく再現するためには、燃えている物の燃焼が進展する状況や、煙・有毒ガスなど燃焼生成物の排出量の時間変化を知ることが不可欠です。しかし、燃焼現象は極めて複雑な化学反応と物理過程によるものであるため、火災の進展を理論的に導き出すことは現在の科学技術では不可能です。

そこでわたしたちは、実験結果にもとづいて、火災拡大に最も寄与する材料の発熱速度や、消防活動・避難の妨げとなる煙や有毒ガスについてのデータを集めた「燃焼実験データベース」を構築し、火災シミュレーションに利用しようと考えています。このデータベースの構築には、過去に実施された各種材料の実験データを活用していますが、不足する部分については、新たに小規模実験や実規模実験を行ってデータを取得しています。

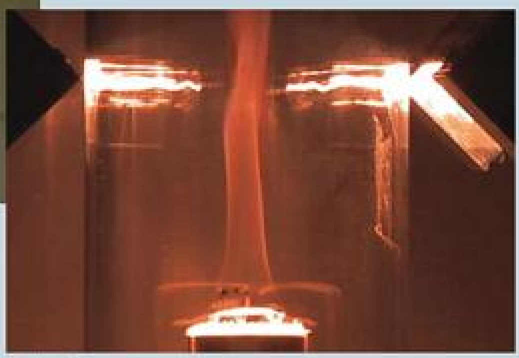
Knowing how the combustion of burning materials progresses and how the amount of smoke and toxic gases they discharge varies over time is essential to having fire simulators accurately reconstruct actual fires. However, it is impossible to logically deduce the development of a fire with our current level of scientific knowledge because combustion consists of extremely complex chemical reactions and physical processes.

Our solution was to use our test results to build the Flammability Test Database, a collection of data on the heat-release rate of materials that contribute the most to the spread of fire, smoke and toxic gases that impede firefighting and evacuation efforts, and then use the database for our fire simulations. We utilized past test data on various materials to build the database, but when additional data is necessary, we conduct small-scale and full-scale tests.

■燃焼実験データベース
Flammability Test Database

http://firedb.fri.go.jp/

実規模燃焼実験
Full-scale fire test



素材燃焼実験
Material-flammability test

006

関東大震災で発生した旋風の絵（東京都復興記念館所蔵）
Picture of a whirlwind that occurred during the fires that followed the great Kanto earthquake
(Memorial Museum for the Kanto Earthquake Disaster)

市街地火災時の「旋風」・「火災旋風」の現象解明をめざして。

Elucidating the phenomena of whirlwinds and fire whirls in urban fires

大規模な市街地火災では、「旋風」と呼ばれる竜巻状の空気の渦（巨大なつむじ風）が発生して大きな被害をもたらすことがあります。この旋風は、人や物を吹き飛ばすだけでなく、その猛烈な風によって急速な延焼を引き起こしたり、火炎を含んだ竜巻状の渦である「火災旋風」に発展したりすることもあります。1923年の関東大震災では、人々が避難していた陸軍被服廠（工場）の跡地であった空き地に旋風が襲来し、この場所だけで約3万8千人もの方が亡くなりました。

火災時に発生する旋風のなかでも、横風が吹いている条件での火災域の風下に発生する旋風はその報告例が非常に多く、被服廠跡を襲った旋風も当時の証言や気象条件、火災状況などからこのタイプのものであった可能性が高いと考えられます。しかし、旋風の発生条件や発生メカニズムはいまだ解明されておらず、その対策も全くとられていないのが現状です。

そこでわたしたちは、火災域の風下に発生する旋風の発生を予測できるよう、その性質・発生メカニズム・発生条件を、さまざまな規模の実験をとおして調べています。これまでの実験で、火災風下の床面（地表面）付近には、旋風の源ではないかと思われる数種類の渦が発生していることがわかってきました。さらに、これらの渦の形成過程には、横風に逆行する空気の流れなど、火炎風下の複雑な流れが関与していることなども明らかになりつつあります。

Larges-scale urban fires can induce large whirling masses of air that cause major damage. These whirling masses of air, known as whirlwinds, not only hurl people and objects through the air, they also rapidly spread flames due to their fierce winds and can even develop into fire whirls in which flames become part of the whirlwind itself. In the 1923 great Kanto earthquake, a whirlwind swept through the empty lot of an old army clothing factory where people had sought shelter, resulting in some 38,000 deaths at that one site alone.

According to reports, an extremely high number of whirlwinds occur downwind from fires in a crosswind. The whirlwind that swept across the clothing factory site following the great Kanto earthquake was most likely of this type, based on testimonies, the weather conditions and fire condition, etc. However, the conditions and mechanisms for the formation of such whirlwinds are still unclear, and no progress has been made to implement measures to prevent them.

We are, therefore, conducting experiments of varying sizes to study the nature of such whirlwinds, and the conditions and mechanisms that allow them to occur during fires, to enable the predictability of their occurrence. In our experiments thus far, we discovered that several types of vortices that we believe may be the source of whirlwinds occur near the ground surface downwind from a flame. We also discovered that complex airflows moving downwind from a flame, including the airflow traveling in the opposite direction of crosswinds, contribute to the formation of these vortices.

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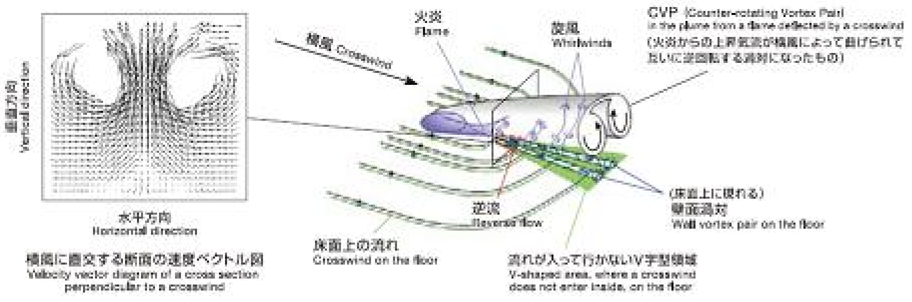
「旋風」の実験。横風中の火炎風下に発生した旋風が、床面上に流した白煙で可視化されている。
Whirlwind experiment. Whirlwinds occurring downwind from a flame during a crosswind are made visible using white smoke released on the floor.

「火災旋風」の実験。水平方向に風速が変化する横風中におかれた複数の火炎から火災旋風が発生している。
Fire whirl experiment. A fire whirl results from multiple flames in a crosswind in which the wind changes in a horizontal direction.

横風中の火炎風下の空気の流れ

Airflow moving downwind from a flame during a crosswind




防火服の耐熱性能評価に用いるサーマルマネキン
A thermal mannequin used to assess the heat resistance performance of protective clothing

「ナノテク」を用いた、消防用防火服の研究。
Research on protective clothing for firefighters using nanotechnology

生死を分ける危険な災害現場で活動する消防隊員。彼らにとって消防用防火服は、最も重要な命綱といえます。そのため現在の防火服は、耐熱性能を強く求めるあまりゴワゴワとした生地になり、着用したときの快適性や機能性が損なわれていることも事実です。これまでわたしたちは、防火服の耐熱性・快適性・機能性の3性能について測定と解析を行い、わが国における防火服の性能基準値を提案してきました。これまでも、これら防火服の3性能の向上をめざし、既存のさまざまな素材を用いた防火服の開発が試みられていますが、行き詰まっているのが現状です。

消防隊員の安全を約束し、かつ効果的な活動を実現する防火服の開発。この防火服の画期的な進化を実現すべく、わたしたちはナノ素材・ナノコーティングなどの「ナノテク」を活用した消防用防火服の研究を進めています。また、「ナノテク」防火服に求められる耐熱性・快適性・機能性などを評価する新たな方法・基準の検討や、繊維の物性値を入力することで防火服の耐熱性が予測できるシミュレーションプログラムの開発も計画しています。

Firefighters work at dangerous disaster sites where their lives are put at risk. For these firefighters, protective clothing can easily be called the most important lifesaver available to them. The fabric of such clothing is very stiff due to the high heat resistance that is demanded. This makes it uncomfortable and not very functional to wear. We have thus far measured and analyzed the heat resistance, comfort, and functionality of protective clothing, and based on the findings, have proposed standard values for the performance of such clothing in Japan. In an attempt to raise heat resistance, comfort, and functionality performance, attempts have been made to develop protective clothing using a variety of existing materials, but progression is currently at a dead end.

The development of new protective clothing promises to protect firefighters and help them perform firefighting effectively. In an effort to spark a groundbreaking evolution in protective clothing, we are pursuing research in this area using nanotechnology, for example nanomaterials and nanocoatings. We are also studying new methods and standards for evaluating the heat resistance, comfort, and functionality demanded for nanotechnology-based protective clothing, and are planning the development of a simulation program that can predict the heat resistance of protective clothing by entering the physical parameters of the fabric from which it is made.

サーマルマネキン試験による各種防火服の火炎に対する防護性能
Protection performance of various types of protective clothing based on thermal mannequin tests

防火服の種類 Type of protective clothing	下着の有無 Wearing underwear	半袖Tシャツの有無 Wearing short sleeve undershirt	活動服のズボン有無 Wearing work pants	暴露時間（秒） Exposure time (sec.)	重症度 Burn severity
日本防火服 Japanese protective clothing	有 Yes	無 No	有 Yes	5	軽症 Light
	有 Yes	無 No	有 Yes	6	軽症 Light
	無 No	無 No	無 No	8	軽症 Light
	無 No	有 Yes	有 Yes	6	軽症 Light
	無 No	有 Yes	有 Yes	7	軽症 Light
	無 No	有 Yes	有 Yes	8	中等症 Moderate
	有 Yes	無 No	有 Yes	8	中等症 Moderate
	無 No	無 No	無 No	8	中等症 Moderate
米国防火服 American protective clothing	有 Yes	無 No	有 Yes	5	火傷無 No burning
	有 Yes	無 No	有 Yes	8	軽症 Light
	無 No	無 No	無 No	8	中等症 Moderate

火傷の重症度の基準（小児、老人を除く）
Standards for burn severity (excluding small children and the elderly)

重症度 Severity	体表面積に対する3度火傷割合（%） Ratio of Third degree burns to body surface area (%)	体表面積に対する2度+3度火傷割合（%） Ratio of Second degree + Third degree burns to body surface area (%)	対応 Treatment
重症 Severe	10以上 10% or more	30%以上 30% or more	専門施設に入院を要する Requires hospitalization at a special burn center
中等症 Moderate	2～10%	15～30%	一般病院に入院を要する Requires hospitalization at a general hospital
軽症 Light	2%未満 Less than 2%	15%未満 Less than 15%	外来治療が可能 Can be treated on an outpatience basis

サーマルマネキン試験による火傷度の時間変化
Change in ratio of first, second and third degree burns over time based on thermal mannequin tests

研究紹介
Research
2

化学物質の火災爆発防止と

Preventing and extinguishing chemical fires and explosions

消防法では、ガソリン"や"灯油"のような火がつきやすい物質や、一度火がつくと急激に燃え広がるなど消火のしにくい物質を「危険物」と定義し、さまざまな安全対策がとられてきました。しかし、科学技術の進歩や、環境問題への取り組みの発展にともない、火災や爆発の危険性が十分把握されていないリサイクル資源や新たな工業材料が誕生し、「危険物」として新たに追加されるべきものが出現しています。わたしたちは、新しい物質の危険性を解明したり、消火技術を確立したりするなど、より安全な社会の実現をめざした研究開発を行っています。

The Fire Service Law defines substances that easily ignite, such as gasoline and kerosene, and substances that are difficult to extinguish, such as those that once ignited cause flames to spread rapidly, as hazardous materials. A variety of safety measures have traditionally been taken to control such substances. However, with the advances being made in scientific technologies and the development of efforts to solve environmental issues, we are seeing the emergence of recycled resources and new industrial materials that are not fully understood in terms of their potential to cause fires and explosions. These new materials must be added to the growing list of those considered hazardous. We are conducting R&D, including efforts to elucidate the hazards of new materials, and are establishing new firefighting technologies, in an effort to ensure an even safer society.

危険物質の危険性評価の研究。

Risk assessment research on hazardous materials

近年、化学工業、石油工業、廃棄物産業における火災や事故が多発しています。わたしたちは、その原因調査と発災物質の危険性評価を行っています。たとえば、わたしたちの実験結果から、半導体の洗浄や医薬品・農薬の合成に使われている化学物質のヒドロキルアミンが、ダイナマイトに匹敵する爆発力を持っており、鉄など金属イオンが存在すると不安定になって急激な爆発を起こし得ることがわかりました。これらの成果は、2001年の消防法の改正につながり、ヒドロキシルアミンを貯蔵する施設には、設置場所や構造、資格を持った管理責任者の配置、防火壁設置などの規制がかけられることになりました。

危険物の危険性評価の分野においては、国際的な協調が不可欠です。わたしたちは、国内外の大学、研究機関などと積極的に共同研究を行っており、その一環として「ラウンドロビン試験」に参画しています。これは、世界の多数の研究機関が同一の試験方法、同一の試料で、物質の危険性評価に関する試験を行うことにより、その試験方法の普遍性を評価するものです。

2000年 群馬県の化学工場におけるヒドロキシルアミン爆発事故
Hydroxylamine explosion at a chemical plant in Gunma Prefecture in 2000

■ヒドロキシルアミンの「爆ごう」試験の結果
Results of detonation test for hydroxylamine

ダイナマイトなどの爆薬が爆発するときのような、音と衝撃波をともなう激しい燃焼を「爆ごう」と呼ぶ。ヒドロキシルアミンでも爆ごうが生じた。
Violent combustion accompanied by a loud bang and shock wave, similar to what happens when dynamite and other such substances explode, is known as a detonation. Hydroxylamine has potential to result in a detonation.

■ヒドロキシルアミン水溶液の燃焼実験結果
Results of a combustion test on a hydroxylamine solution
ヒドロキシルアミン85%水溶液に鉄イオン0.5%水溶液(1g)を添加した場合の燃焼状況
State of combustion after adding an aqueous solution of which 0.5% consists of iron ions (1g) to an aqueous solution of which 85% consists of hydroxylamine

滴下0.7秒後
0.7 sec. after adding

0.9秒後
0.9 sec. after adding

1.7秒後
1.7 sec. after adding

2.3秒後
2.3 sec. after adding

2.9秒後
2.9 sec. after adding

18.7秒後
18.7 sec. after adding

ほぼ一瞬にして火炎が吹き上がる。Mixture ignites almost instantaneously

The chemical, oil, and waste industries have experienced numerous fires and accidents in recent years. We study their causes and performs risk assessments on materials that have the potential to cause disasters. Based on our test results, it was found, for example, that hydroxylamine, a chemical substance used in the washing of semiconductors and the synthesis of pharmaceuticals and pesticides, has the equivalent explosive force of dynamite, and that when in the presence of metal ions, such as iron, it becomes unstable and may suddenly explode. The results of this research led to the 2001 revision of the Fire Service Law in which regulations were set in place for facilities that store hydroxylamine. These regulations are related to their location and structure, the deployment of qualified administrators and the installation of firewalls.

International collaboration is indispensable in the field of risk assessment for hazardous materials. We actively pursue joint research with domestic and overseas universities and research labs, and as part of these efforts, are participating in round-robin tests. In these tests, research labs from around the world use the same test methods and samples to conduct risk assessment tests on substances, and based on their findings, they assess the universality of such test methods.

009

消火

2003年 神奈川県における生ゴミ処理設備での爆発事故
Explosion at raw garbage treatment facility in Kanagawa Prefecture in 2003

廃棄物と廃棄物処理施設の危険性評価。
Risk assessment for waste and waste treatment facilities

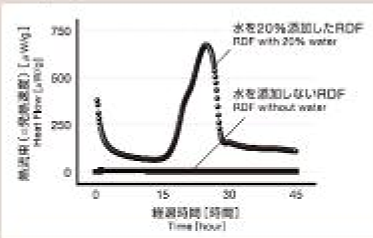
最近、大量に貯蔵されている廃棄物やその処理施設で発生する火災・事故が増加しています。廃棄物処理施設は、粉砕などの工程で生じる衝撃火花・摩擦火花、または化学反応などが出火原因となって、大きな災害に発展してしまう危険をかかえています。わたしたちは、これらの発火に至るプロセスを解き明かすとともに、火災の特性に応じた火災予防策と消火システムの研究開発を進めています。

また近年、地球環境に配慮して廃棄物などを再利用する取り組みが進められ、バイオマス燃料をはじめとする多くの再生資源燃料が誕生しています。しかし、これらのなかには、大量貯蔵時に蓄熱発火するなど、危険性がよくわからないものも多くあります。わたしたちは、再生資源燃料の危険性の評価を行うなど、「安全なリサイクル」の実現に向けた研究も行っています。

再生資源燃料等の例
Examples of reusable fuels

再生資源燃料 Reusable fuel	原料 Source	用途例 Example of usage
木質ペレット Wood pellets	木材 Wood	暖房用ボイラーの燃料 Fuel for heating boilers
汚泥燃料 Sludge-based fuels	下水処理時に発生する汚泥 Sludge generated during wastewater treatment	石炭火力発電所の燃料 Fuel for coal-fired power plants
RDF	プラスチック、家庭ごみ Plastics and household waste	RDF発電設備の燃料 Fuel for RDF power generating facilities
RPF	プラスチック、紙、産業廃棄物 Plastics, paper, and industrial waste	RPF発電設備の燃料 Fuel for RPF power generating facilities
鶏糞 Poultry manure	養鶏場から発生する鶏糞 Manure generated at poultry farms	発電設備の燃料 Fuel for power generating facilities

RDF（ゴミ固形化燃料）の発熱速度の測定結果
Measurement results for the heat release rate of refuse-derived fuel (RDF)



RDFに水を添加すると発酵が進み、発熱するおそれがあることがわかった。
We found that adding water to RDF promotes fermentation and can cause heat release.

The number of fires and accidents occurring at facilities that store and treat vast quantities of waste has been on the rise in recent years. Sparking from impact and friction as well as the chemical reactions that arise in the processes carried out at waste treatment facilities can result in fires that may potentially develop into major disasters. We are elucidating the processes that lead to the ignition of waste and conducting R&D on fire prevention measures and firefighting systems tailored to the characteristics of specific types of fires.

In addition, environmentally conscious efforts related to waste reuse have been on the rise in recent years, and many renewable fuels, including biomass fuels, are emerging. However, their associated hazards, including the risk of ignition from heat buildup when storing large quantities, are largely unknown. We also conduct research on implementing "safe recycling," and assess the hazards associated with renewable fuel.

生ゴミ処理設備での爆発事故の再現実験
Test for reproducing an explosion at a raw garbage treatment facility

生ゴミに含まれる油と水の割合が発火開始時間に大きく影響することがわかった。
We discovered that the ratio of oil to water in raw garbage had a dramatic impact on the time of ignition.

2003年 十勝沖地震により苫小牧市の製油所で発生したナフサタンクの全面火災
Full-surface fire in an oil refinery's naphtha tank in Tomakomai after the 2003 Tokachi-oki earthquake

011

石油タンク火災の性状解明と効果的な消火方法

Elucidating the nature of oil tank fires and finding effective methods to extinguish them

2003年十勝沖地震では、苫小牧市の製油所でナフサタンクの「全面火災」が発生しました。「全面火災」とは、タンクの中の石油が全面大気に露出し、そこから炎が立ち上がる火災のことで、消火は困難を極めます。このタンク火災は44時間も燃え続け、社会に大きな衝撃を与えました。

この火災をきっかけとして、わたしたちは、石油など可燃性液体の火災に対する、より効果的な消火方法についての研究をはじめました。石油タンク火災の消火には、燃焼表面を泡で覆って空気を遮断する「泡消火剤」が使われます。わたしたちは、タンク全面火災に対する効果的な泡消火方法を探るため、実物のタンクや模型タンクでの泡消火実験を行っています。また、泡消火剤の基本的な性質や石油類の燃焼性状（周囲へ伝わる熱の激しさ、燃え方、炎の熱さ、煙の量など）の解明も同時に進めています。これは、効果的な消火方法を追究する上で基礎となる大切な研究です。

小型模型タンクを使ったボイルオーバーの実験
Boil-over experiment in a small model tank

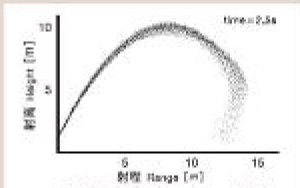
In the 2003 Tokachi-oki earthquake, there was a full-surface fire in a naphtha tank at an oil refinery in the city of Tomakomai. A full-surface fire refers to a fire in which the entire surface area of oil within a tank is exposed to the atmosphere and the oil burns. These types of fires are extremely difficult to extinguish. In this case, the tank fire raged for 44 hours and had a major impact on Japanese society.

Spurred by this fire, we commenced research on more effective methods to extinguish fires caused by flammable liquids, including oil. Oil tank fires are extinguished by covering the burning surface area with fire-fighting foam, thereby cutting off the fire's oxygen supply. We are conducting experiments on actual and model tanks in an effort to explore effective methods for foam-based firefighting in full-surface fires. At the same time, we are working to shed light on the basic characteristics of firefighting foam and the nature of petroleum combustion, including the intensity of heat transmitted to the surrounding area, how such substances burn, the flame temperature and the amount of smoke. This important research is fundamental to the investigation on effecting firefighting methods.

燃料の蒸発速度と火災挙動の関係を把握するための実験
Experiment for determining the relation between the fuel evaporation rate and fire behavior

泡放水砲の放水挙動に関する予測

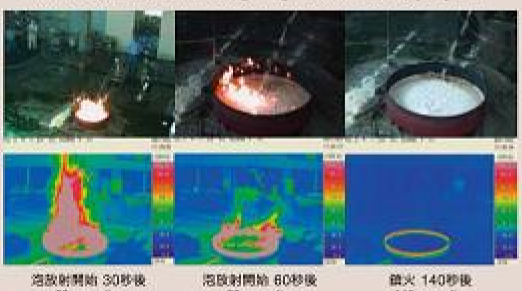
Forecasting the water-stream quality of a foam monitor



放水軌跡の数値シミュレーション結果
Results of a numerical water-stream trajectory simulation

「泡消火剤」の消火性能実験

Evaluation experiment on the fire extinguishing effectiveness of fire-fighting foam



泡放射開始 30秒後 / 30 sec. after start of foam ejection
泡放射開始 60秒後 / 60 sec. after start of foam ejection
鎮火 140秒後 / 140 sec. after fire is extinguished

実大実験 An actual test

ガス系消火剤に関する研究

Research on gaseous fire suppressants

消火時の水損が致命的な問題となるコンピュータ室、通信機器室、図書館、美術館などには、ガス系消火剤を使用する消火設備が数多く設置されています。これまでガス系消火剤として長年使用されてきたハロン消火剤は、地球のオゾン層を破壊する物質として国際的に生産が禁じられたため、現在ではオゾン層破壊の原因となる塩素、臭素を含まないフッ化炭化水素系の消火剤や、不活性ガスからなる消火剤が使われています。しかし、これらの新消火剤は、ハロンと比較して消火性能が劣るため、各消火剤の特質をよく理解した上で使うことが重要です。また、これら消火剤のなかには、ある条件の下では逆に可燃物の着火を促したり、フッ化水素など人体に有毒な燃焼排出物の生成を促進したりする場合があることが知られています。

わたしたちは、これらの消火剤を安全に使用できるようにするために、着火･消炎現象と燃焼排出物生成過程など消火剤のさまざまな作用を解明する研究を進めてきました。また、ガス系消火剤の基礎研究として、「対向流拡散火炎バーナー」と呼ばれる装置を試作して実験を行い、液体可燃物に対する各種消火剤の消炎性能や消炎現象そのものを明らかにする研究も行ってきました。

現在わたしたちは、窒素富化空気による火災の消火システムの開発をめざしています。これは、窒素濃度の高い（酸素濃度の低い）空気を閉鎖空間に大量に注入することにより、火災の抑制または消火を行うもので、廃棄物施設での火災などに有効であると考えています。

Fire extinguishing equipment that uses gaseous fire suppressants is provided in computer rooms, communication equipment rooms, libraries, museums, and other places where water damage from firefighting would be disastrous. The production of halon, which had a long history of use as a gaseous fire suppressant, has been banned internationally because it destroys the Earth's ozone layer. Fluorohydrocarbon agents that do not contain bromine or chlorine atom, and inert gases are now being used instead. However, these new extinguishing agents do not perform as well as halon, hence it is very important to ensure that their characteristics are completely understood before using them. Some of them are also known to promote ignition under certain conditions, and cause the release of combustion emissions, such as hydrogen fluoride, that are toxic to the human body.

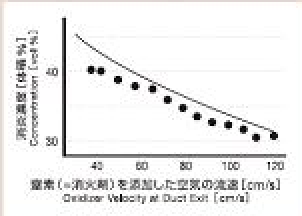
To ensure the safe use of such fire suppressants, we have conducted research aimed at elucidating their various actions, including the ignition/extinguishing phenomena and processes behind the release of combustion emissions. As part of our basic research on gaseous fire suppressants, we are performing experiments using a counterflow diffusion flame burner and are conducting research in an effort to shed light on the extinguishing performance and extinction phenomenon of various types of fire suppressants on flammable liquids.

We are now seeking to develop a fire extinguishing system that uses nitrogen-enriched air. This system suppresses or extinguishes fires by injecting vast quantities of air that has a high nitrogen concentration (and a low oxygen concentration) into a confined space. We believe this will prove effective in fighting fires at waste treatment facilities and other such locations.

対向流拡散火炎バーナー
Counterflow diffusion flame burner

012

■コンピュータ数値シミュレーションによる窒素を添加した空気の消炎濃度（＝火炎が消える窒素の濃度）の予測
Predictive computer simulation of the concentration of nitrogen that will extinguish a fire



数値シミュレーションから予測される消炎濃度（実線）は、実験から得られた消炎濃度（●）とよく一致している。
The concentration that will extinguish a fire (solid line), as predicted by the computer simulation, closely matches the concentration (large dot) obtained in our tests.

■対向流拡散火炎バーナーを使った窒素による消炎実験
Flame extinguishing experiment with nitrogen using a counterflow diffusion flame burner

空気流中に窒素15%を添加（消炎せず）
15% nitrogen added to airflow
(no extinguishment)

空気流中に窒素25%を添加（消炎せず）
25% nitrogen added to airflow
(no extinguishment)

空気流中に窒素27%を添加
（消炎寸前の状態になった）
27% nitrogen added to airflow
(flame about to be extinguished)

3 研究紹介 Research 石油タンクの地震防災と経年

Protecting oil tanks against earthquake disasters and age-related deterioration

地震多発国、日本。わが国の石油タンクは、これまで幾度となく地震の被害を受けてきました。また、石油タンクが数多く設置されている臨海部は、鋼鉄製のタンクにとっては腐食などにより劣化しやすい厳しい環境です。ここ十年間、石油タンクの腐食による油の漏洩事故は増加傾向にあります。わたしたちは、石油タンクの安全性をより向上させられるよう、地震発生直後に石油タンク本体や浮き屋根が受ける被害を推定して緊急対応に役立てたり、石油タンクの経年劣化の状態を診断したりするための研究を行っています。

In our earthquake-prone country of Japan, oil tanks have been damaged by earthquakes on numerous occasions. Furthermore, coastal areas where great numbers of oil tanks are located have harsh environments that are conducive to the corrosion of steel tanks. In recent years, there has been an upward trend in accidents involving oil leaks caused by tank corrosion. In an effort to enhance the safety of oil tanks, we are conducting research on estimating the damage to the main body of oil tanks and their floating roofs immediately after an earthquake to be able to respond to emergency situations. We are also conducting research on the diagnosis of age-related deterioration of oil tanks.

石油タンク底部の、腐食状態を診断する。

Diagnosis of corrosion at the bottom of oil tanks

石油タンク底部の腐食が進むと、穴が開いたり、地震により破損したりすることで大量漏洩事故のおそれが出てきます。現在、石油タンクの腐食状態の診断は、約10年に一度、タンクを空にして超音波でタンク底部の鋼板の厚さを測定するという「開放検査」で行っています。しかし、この方法では石油タンクを空にする必要があるだけでなく、腐食している箇所を全て発見するには非常に多くの労力が必要となります。

そこでわたしたちは、「AE波」を使って、石油タンク底部全体の腐食状況を診断する方法の開発に取り組んでいます。この方法では、石油タンクを空にする必要がなく、短時間で診断ができる可能性があります。この診断技術が確立されると、石油タンク稼働中に検査を行ったり、腐食が進んでいると診断されたタンクのみ早急に精密検査を行い、そうでないタンクについては開放検査を先送りにしたりすることができるなど、効果的で効率がよい検査体制が可能になります。

「AE波」とは、腐食の活性度に応じて放出される微弱な弾性波のことです。これは、タンク各部位で腐食生成物質がはがれたり、割れたりすることにより発生すると考えられています。「AE波」は、タンクの外側に貼り付けたセンサーで検出することができます。これまで、実際の石油タンクを使って「AE波」の測定実験を繰り返してきました。その結果、石油タンク底部の「腐食危険度」が大きくなるにつれて「AE活動度」も大きくなるという関係を定量的に把握することができました。この関係を使えば、「AE波」の測定から腐食程度の推定が可能になります。

When the bottom of an oil tank corrodes, there is the potential for massive leaks if a hole develops or the tank is damaged by an earthquake. At present, the diagnosis of oil tank corrosion is performed once every ten years by emptying the tank and then using an ultrasound to measure the thickness of the steel plates in the tank's base. However, this method not only requires the oil tank to be emptied, it also requires a great deal of effort in finding all points of corrosion.

In response to this, we are developing a method for diagnosing corrosion at the entire bottom of oil tanks using acoustic emission (AE) waves. Such a method would have the potential for rapid diagnoses to be made, without having to empty the tank. If such diagnostic technology were to be established, highly effective and efficient inspection systems would become possible. This would include the inspection of oil tanks while they are still operating, the rapid and detailed inspection of only those tanks in which advanced corrosion is detected, and the postponement of inspections in tanks in which no corrosion has occurred.

AE waves are faint elastic waves emitted in response to corrosion activity. They are believed to result from the peeling off and splitting of the substances formed by corrosion on various parts of the tank. These AE waves can be detected using sensors attached outside the tank. We have been continuously performing measurement experiments on AE waves using actual oil tanks. Our results have enabled us to quantitatively identify the relationship whereby AE activity grows as the risk of corrosion on the tank base increases. Based on this relationship, we are able to estimate the degree of corrosion using AE wave measurements.

1978年　宮城県沖地震で石油タンク底部に生じたき裂。腐食していた石油タンクが強い揺れを受けたことが原因と考えられている。

Crack that occurred at the bottom of an oil tank during the 1978 Miyagi-ken-oki earthquake. It is believed the crack resulted from the strong shaking of the corroded oil tank.

石油タンク側板に取り付けられたAE波センサー

AE wave sensors attached to the shell plate of an oil tank

■開発したニューラルネットワークによるAE源位置評定ソフトウェア

Software used to locate sources of AE waves by means of a neural network that we have developed

劣化対策

地震時に「浮き屋根」がどのように揺動するか把握する。

Understanding how "floating roofs" shake during earthquakes

石油タンクが、周期数秒から十数秒の「やや長周期地震動」と呼ばれる地震の揺れに見舞われると、タンク内部の石油の液面が大きく揺れることがあります。これを「スロッシング（液面揺動）」といいます。石油タンクのなかには、屋根を内容液に浮かせた「浮き屋根」式と呼ばれるタイプがあり、スロッシングが起きるとこの「浮き屋根」も揺動することになります。2003年十勝沖地震の際、苫小牧市にある石油タンクでは、「浮き屋根」が大きく揺動し、揺れ幅は最大3mにも達しました。その結果、「浮き屋根」は破損して油の中に沈没し、タンクの油が大気に露出するという大変危険な事態となりました。このような被害を受けたナフサタンクでは、約44時間燃え続けるという大火災が発生しました。

「浮き屋根」の沈没被害をなくすためには、どのような対策を施せばよいのか？「浮き屋根」は、どの程度の揺動でどれくらいの損傷を受けるのか？これらの問題を解決するには、地震時の「浮き屋根」の揺動状況を詳しく把握しなくてはなりません。そこでわたしたちは、小規模の模型タンクや、実物の石油タンクを使って、「浮き屋根」の揺動実験を行っています。この結果、スロッシングの波高の予測精度を向上させたり、「浮き屋根」がスロッシング波高に及ぼす影響を評価したりすることに役立つデータが得られつつあります。

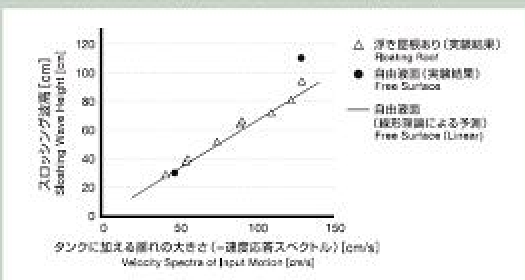
実際の浮き屋根式石油タンクを用いた浮き屋根の揺動実験
Experiment to assess the behavior of a floating roof in liquid sloshing in an actual oil tank

When oil tanks are shaken due to long-period (several seconds to more than ten seconds) strong ground motions, the surface of oil inside tanks may swing dramatically. This is known as sloshing. Some oil tanks have "floating roofs" in which the top cover or roof floats on the oil within. When sloshing occurs, the floating roof shakes as well. During the 2003 Tokachi-oki earthquake, the "floating roof" of oil tanks in the city of Tomakomai shook dramatically (maximum sloshing wave height of 3 m). This resulted in the damaging of the floating roofs, which ended up sinking into the tanks. This was an extremely dangerous situation because the oil was exposed to the atmosphere. The naphtha tank that suffered such damage burned fiercely for some 44 hours straight.

What sort of measures should be taken to prevent the damage and sinking of "floating roofs?" How does the degree of shaking correlate to the amount of damage to "floating roofs?" Solving such problems requires an in-depth understanding of the shaking of "floating roofs" during earthquakes. To that end, we are conducting shaking experiments for "floating roofs" using small model tanks and actual oil tanks. As a result, we are gaining data useful for improving the ability to accurately predict the sloshing wave height and assessing the effects of floating roofs on sloshing wave heights.

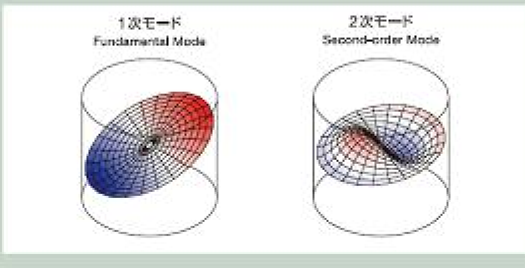

2003年 十勝沖地震で「浮き屋根」が沈没した苫小牧の石油タンク
Tomakomai oil tanks in which the floating roofs sunk during the 2003 Tokachi-oki earthquake

■模型タンク浮き屋根揺動実験結果：タンクに加える揺れの大きさとスロッシング波高の関係
Experiment results on the shaking of a floating roof on a model tank: Relation between the intensity of the shaking applied to the tank and the sloshing wave height



タンクに加える揺れを大きくした場合に生ずるスロッシングの波高は、比例関係から外れて大きくなる傾向があることがわかった。
We found that the wave height of sloshing due to a high level of shaking being applied to the tank tended to deviate greatly from a linear relationship.

■スロッシング発生時の石油タンクの液面形状（数値シミュレーションによる）
Oil surface shape in a sloshing tank (computer simulation)



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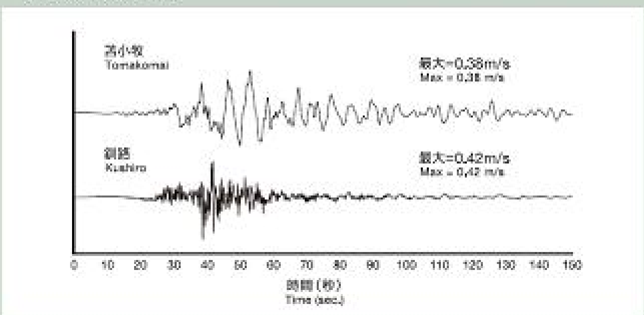
1964年 新潟地震の際の新潟市の製油所における石油タンク火災（写真提供：防衛省）
Oil tank fire at a refinery in Niigata following the 1964 Niigata earthquake
(Photo provided by courtesy of the Ministry of Defense)

「やや長周期地震動」を予測する。
Predicting long-period strong ground motions

周期数秒から十数秒の「やや長周期地震動」を原因とする石油タンクのスロッシング被害は、2003年十勝沖地震以前にも、1964年新潟地震の際の新潟の製油所、1983年日本海中部地震の際の秋田の発電所で発生しています。わたしたちは早くから「やや長周期地震動」に注目し、研究を進めてきました。

「やや長周期地震動」の発生のしかたには、大きな地域差が見られます。たとえば2003年十勝沖地震では、苫小牧で観測された大きな「やや長周期地震動」も、釧路では観測されませんでした。わたしたちはこれまで、各地の気象台や測候所で蓄積されている過去の地震記録を使って、地域ごとに「やや長周期地震動」の特性を分析してきました。その結果、たとえば日本海東縁部で地震が発生すると、新潟では周期約10秒の揺れがとくに大きくなることなどが明らかになりました。これらの結果を使えば、石油タンクが立地する各地域の「やや長周期地震動」の最大レベルを予測することができます。この研究成果は、2003年十勝沖地震の後に改正された消防法令の石油タンクの技術基準に採り入れられ、新潟など「やや長周期地震動」が大きく出ると予測される地域については、基準が強化されました。

2003年 十勝沖地震の際に苫小牧で観測された「やや長周期地震動」（地動速度波形）
Long-period strong ground motions observed in Tomakomai during the 2003 Tokachi-oki earthquake (ground velocity waveform)

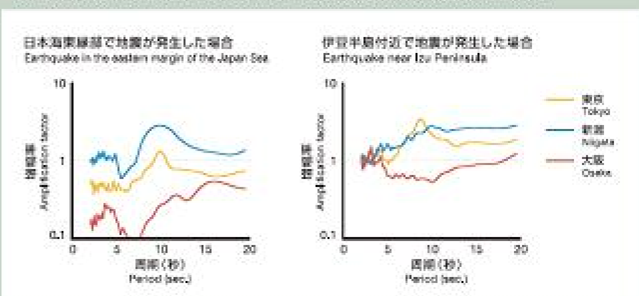


（独立行政法人防災科学技術研究所強震観測網K-NETのデータから作成）
(Created based on data from the National Research Institute for Earth Science and Disaster Prevention)

Sloshing damage in oil tanks, which results from long-period (several seconds to more than ten seconds) strong ground motions, occurred not only during the 2003 Tokachi-oki earthquake, but also during the 1964 Niigata earthquake at a refinery in Niigata, and during the 1983 Japan Sea earthquake at a power plant in Akita. We focused early on long-period strong ground motions and have pursued research in that area for many years.

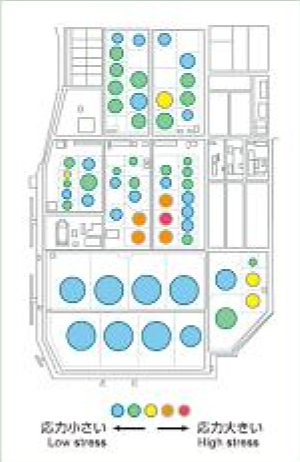
Significant regional variation can be seen in how long-period strong ground motions occur. For instance, during the 2003 Tokachi-oki earthquake, the large-amplitude long-period ground motions observed in Tomakomai were not observed in Kushiro. Using seismograms amassed at meteorological observatories in various regions, we have analyzed the characteristics of long-period strong ground motions in each region. As a result, we now know that, for example, when an earthquake occurs in the eastern margin of the Japan Sea, an approximate 10-second period of shaking will be particularly amplified in Niigata. Using these results, we can predict the maximum level of long-period strong ground motions for future earthquakfs in each area where oil tanks are located. These research results were adopted in revising the seismic design intensity for oil tanks in the Fire Service Law following the 2003 Tokachi-oki earthquake. The seismic design intensity was increased for regions in which large long-period strong ground motions are predicted, such as Niigata.

「やや長周期地震動」の増幅特性の解析例
Analysis examples for the amplification characteristics of long-period strong ground motions



石油タンクサイトにおける「揺れ」の情報から、石油タンクの被害を推定する。

Estimating tank damage based on information on shaking at oil tank sites

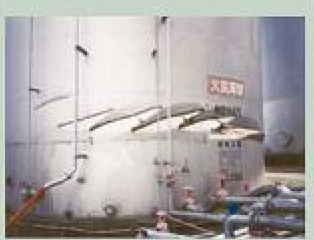


強震動予測結果にもとづいて石油タンクの側板に発生する圧縮応力を計算した結果の一例。
Example of calculation results on axial compressional stress occurring in the shell plates of an oil tank, based on predicted strong ground motions.

大地震が発生した場合、石油タンクが立地する場所（石油タンクサイト）はどのような揺れに見舞われるか？これを予め想定しておくことは、タンク被害の予防対策をうつ上で必要不可欠です。また、実際に地震が起きた時には、石油タンクサイトの揺れをいちはやく知り、どの程度の被害が心配されるか推定することができれば、災害を最小限に食い止めることに役立ちます。

このためわたしたちは、実際に石油タンクサイトに地震計を設置して、揺れの情報を準リアルタイムに集めるシステムの開発に取り組んでいます。また、大地震発生時の石油タンクサイトでの強い揺れ（強震動）を事前に予測する研究も行っています。強震動の予測は、各地の石油タンクサイトに設置している地震計のデータなどを使って行っています。これまでに、将来的に発生確率が極めて高いといわれている想定宮城県沖地震が発生した場合の、仙台地域の石油タンクサイトでの強震動を予測しました。実際に1978年に起きた宮城県沖地震では、仙台の製油所で石油タンク底部が強震動により損傷し、重油が大量に漏洩する事故が発生しています。

わたしたちは、これらの「揺れ」の情報にもとづいて石油タンクに発生する力やスロッシング波高などを計算することにより、タンクの被害を地震発生前に想定したり、地震発生後にすばやく推定したりすることができる防災情報システムの開発を進めています。



1995年 阪神・淡路大震災で強震動の影響により側板が変形（座屈）した石油タンク
Oil tank with shell plates that deformed (buckled) in response to the strong ground motions during the 1995 great Hanshin-Awaji earthquake

When a large earthquake occurs, what sort of shaking will be experienced at oil tank sites? Predicting such shaking is indispensable for establishing safeguards against tank damage. Furthermore, knowing the intensity of shaking at an oil tank as soon as possible and estimating the damage caused to them, will help prevent and mitigate disasters.

To this end, we are installing seismographs at actual oil tank sites in an effort to develop a system that can collect information on shaking in quasi-real time. We are also involved in research on predicting strong ground motions at oil tank sites when large earthquakes occur. The prediction of strong ground motions is being carried out using the data from seismographs installed at oil tank sites in various regions. Thus far, we have predicted the strong ground motions at an oil tank site in the Sendai region during a hypothetical earthquake off the coast of Miyagi Prefecture. It is said that a real earthquake is very likely to occur here in the near future. In the 1978 Miyagi-ken-oki earthquake, the bottoms of oil tanks at a refinery in Sendai were damaged by strong ground motions, causing massive leaks of heavy oil.

We are developing a disaster information system that can predict tank damage before an earthquake strikes and estimate it quickly afterwards, through calculating the stress in tank shell plates and the sloshing wave height using the information on the shaking.

1978年 宮城県沖地震の際の仙台の製油所における重油の大量漏洩事故（写真提供：河北新報社）
Massive heavy oil leak at a refinery in Sendai during the 1978 Miyagi-ken-oki earthquake (Photo provided by courtesy of The Kahoku Shimpo)

研究紹介
Research
4

大規模自然災害時の消防防

Firefighting and disaster prevention in the case of large-scale natural disasters

近い将来マグニチュード8クラスの巨大地震が発生するおそれのある地域が、わが国には数多く存在します。たとえば想定東海・東南海・南海地震が同時に発生すれば、死者約27,000人、経済的損失は約94兆円に上ると予想されています。また急峻な地形がひしめくわが国は、ひとたび豪雨に見舞われると洪水や土石流、地すべりなどの土砂災害が発生しやすく、毎年多くの犠牲者を出しています。このような自然災害から住民の生命・財産などを守る上で、消防活動が重要であることはいうまでもありません。わたしたちは、地震など大規模自然災害時に有効な消防防災活動を実現できるよう、研究開発を行っています。

There are numerous locations throughout Japan that may very well experience a large M-8-class earthquake in the near future. For instance, if earthquakes were to strike simultaneously in the Tokai, Tonankai, and Nankai regions, it is estimated there would be 27,000 casualties and economic losses of some 94 trillion yen. Japan, a highly precipitous nation, is prone to flooding and landslide disasters during heavy rain. Such disasters claim many lives each year. Needless to say, firefighting and disaster prevention efforts are crucial to protecting lives and property from such natural disasters. We are conducting R&D on effective firefighting and disaster prevention efforts to be carried out in case of large-scale natural disasters, such as earthquakes.

同時多発火災発生時の、消防力の最適運用。

Optimum operation of fire brigades against many simultaneous post-earthquake fires

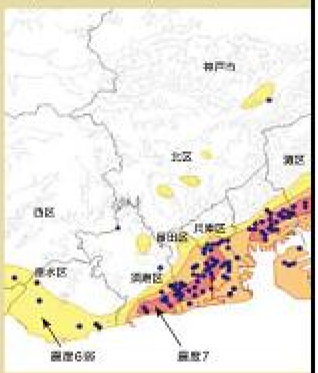
1995年阪神・淡路大震災では、地震に関連して約300件の火災が発生し、その火災によって約500人の方が犠牲になり、約7,000棟の建物が焼失しました。また、東京湾北部の地震を想定した予測では、死者約11,000人のうち、火災で約6,200人もの犠牲者が出るとされています（風速15m/sの場合）。このような同時多発火災への対策としては、木造密集市街地の解消が最も有効ですが、それには大変時間がかかります。このためわたしたちは、同時多発火災が発生した場合の備えとして、消防力を最大限に活用できるよう、最適な消防部隊運用や広域応援を実現するための情報システムが必要であると考えています。

そのための取り組みとして、地震直後にリアルタイムに市街地火災の延焼を予測し、必要消防力、鎮圧可否判断、消防隊駆けつけ時間、消防水利など、さまざまな要素を考慮して、消防力最適運用を可能とするシミュレーションシステムの開発を行っています。また、住民に対する的確な避難指示を支援するための情報システムの開発も進めています。

これらのシステムは、震災時の実運用もさることながら、部隊運用の図上訓練など事前の備えにも役立つものと考えています。

避難場所に迫る火災：1995年 阪神・淡路大震災（写真提供：毎日新聞社）
Fire nearing a refuge area during the 1995 great Hanshin-Awaji earthquake
(Photo provided by courtesy of Mainichi Newspapers)

■1995年 阪神・淡路大震災の際の阪神
Spatial distribution of post-earthquake fires at the



The 1995 great Hanshin-Awaji earthquake resulted in some 300 separate fires that claimed some 500 victims and destroyed some 7,000 structures. A hypothetical earthquake in the northern part of Tokyo Bay has the potential to kill some 11,000, with some 6,200 of them fire victims (assuming a wind speed of 15 m/sec). The most effective measure against such simultaneous post-earthquake fires would be to get rid of the densely built-up areas with wooden structures, but doing so would take a great deal of time. Therefore, we believe an information system for the optimal utilization of fire brigades and the provision of wide-area mutual aid is necessary to enable the use of firefighting resources to the greatest extent possible.

Efforts toward that end cover a broad spectrum and include the immediate prediction of the spread of urban fires in real time following an earthquake, and considering the necessary firefighting resources, estimation of the success and failure of fire control, time needed for fire brigades to arrive at the scene, and water supply. We are keeping all these elements in mind as we develop our simulation system to allow for the optimal utilization of firefighting resources. We are also developing an information system to help provide accurate evacuation instructions to residents.

These systems are useful not only during earthquake disasters, but also when making advanced preparations, such as map exercises for fire brigades and also disaster-prevention offices of local governments.

災活動

複合化消防防災無線システム「FiReCOS」の端末装置
Terminal device for the "FiReCOS" integrated firefighting and disaster radio system

被災地で活動する消防隊どうしの通信と、情報共有の効率化。

Communication and information sharing efficiency between fire brigades at disaster sites

大規模自然災害の被災地では、地元の消防隊に加えて多くの応援部隊が消防活動にあたり、現場では多種多量の情報が複雑にやりとりされます。このような状況では、従来の無線機による音声通信ではおのずと限界が生じます。

このためわたしたちは、PHS移動体通信技術とTCP/IPのネットワーク技術を使って、効率的で輻輳（ふくそう）が発生しにくい消防隊用の通信システム「FiReCOS」の開発を行ってきました。この通信システムでは、音声はもちろん、デジタルデータのやりとりも行えます。また、骨伝導マイクや手を使わないで操作できる機能なども備え、消防隊員にとって使いやすいように工夫されています。

消防隊にとってさらに効率的な通信を実現する可能性を秘めた技術に、「モバイルアドホックネットワーク（MANET）」があります。これは、災害現場のような「ある場面」に集まった端末だけでネットワークを構築し、無線通信を可能にする技術で、消防・警察・軍隊など状況に応じて離合集散して活動する組織に向いているといわれています。わたしたちは、このMANET技術を利用した消防車両どうしの通信システムの開発に取り組んでいます。これにより、「緊急消防援助隊」として各地から被災地に派遣される消防車両の1台が被害などの情報を受信すれば、いっしょに行動している他の車両も、同じ情報を同時に共有することが可能になります。また、被災地の地元消防本部と「緊急消防援助隊」の情報共有が容易になることも期待されます。

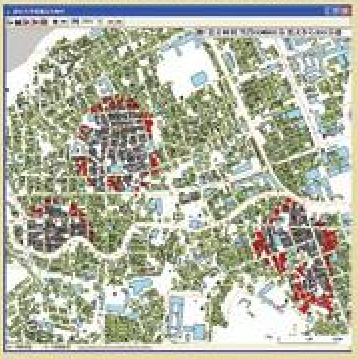
Vast amounts of information of all types are exchanged in the course of the efforts carried out by fire brigades as well as many other support teams in areas where natural disasters strike. Under such conditions, limitations naturally apply to the voice communications carried out using conventional radio technology.

In response, we have developed "FiReCOS" using PHS mobile communication technology and TCP/IP networking. The result is an efficient, congestion-resistant communication system for fire brigades. The system handles not only voice, but also digital data. It provides bone-conduction microphones, hands-free control, and other functions, and is designed for the easy use of fire brigades.

Another technology that holds great promise for effective communications between firefighters is "mobile ad-hoc networks (MANET)." This technology provides wireless communication by building a network configured solely of terminals in a certain area, such as a disaster site, and is believed to be suited to various organizations that split up and assemble as the situation demands, for example the fire brigade, police and military. We are using this MANET technology to develop a communication system between firefighting vehicles. This system will enable a single firefighting vehicle to be dispatched from anywhere in the country to a disaster site as part of an emergency firefighting support team in order to receive information and immediately share it simultaneously with all other vehicles involved in the effort. It is also hoped that the system will make it easier for information to be shared between local fire brigade headquarters at the disaster site and emergency firefighting support teams.

地域での出火点
995 great Hanshin-Awaji earthquake

■市街地火災延焼シミュレーション結果の例
A sample output of results obtained from urban fire spread simulation



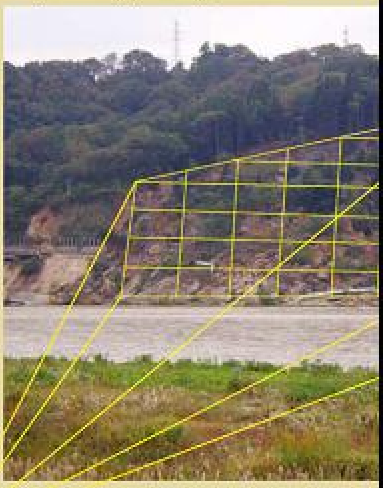
■ 炎上中 Burning structure
■ 焼失 Burned out structure
■ 木造家屋 Wooden structure
■ 非木造家屋 Fire resistive structure
• 防火水槽 Water cistern

■モバイルアドホックネットワーク（MANET）技術を利用した情報共有システム
Information sharing system using a mobile ad-hoc network (MANET)

018

2004年 新潟県中越地震による斜面崩壊地での救助活動と上の崖を監視する消防隊員
Rescue effort at site of slope collapse caused by the 2004 Niigata Chuetsu earthquake and firefighters observing the cliff above

■レーザースキャナによる斜面監視システム
Slope monitoring system using a laser scanner



崖崩れなど、土砂災害現場における救助活動支援。
Support for search and rescue efforts at landslide disaster sites

019

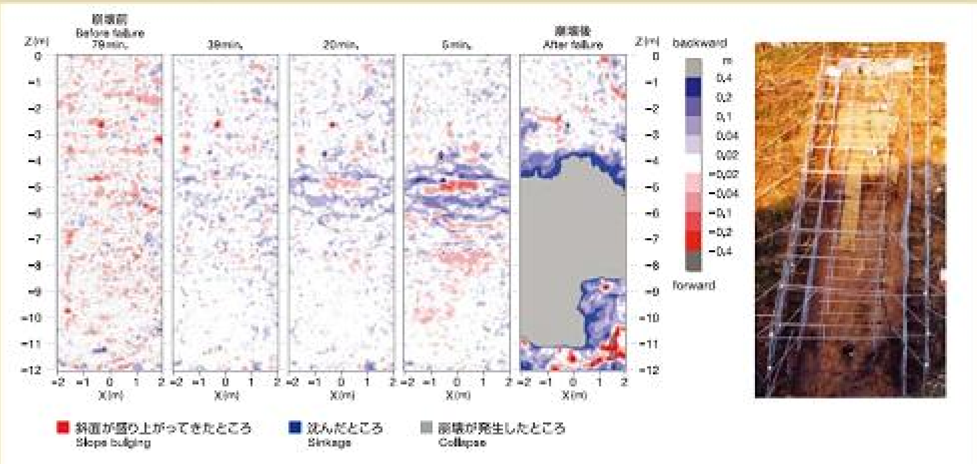
わが国では、平均して年間約50人の方が崖崩れや斜面災害で亡くなっており、主要な自然災害の一つとなっています。崖崩れなどの被災地周辺で救助活動にあたる場合、最も注意しなければならないのは、二次災害の防止です。このために現在行われているのは、主に人の目による斜面の監視ですが、この方法では、とくに夜間は見える範囲が限られたり、長時間監視していると注意力が落ちて、ゆっくりした変化を感じにくくなったりするなどの問題があります。

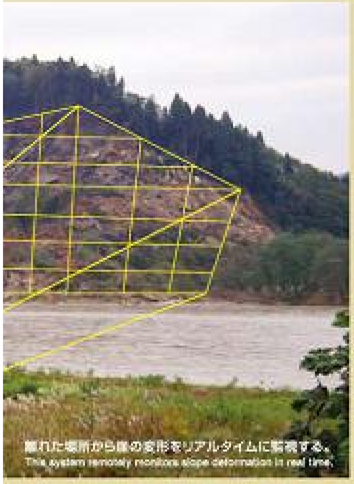
そこでわたしたちは、目視に代わる監視手段として、レーザースキャナを使って斜面の変化を遠隔から感知する手法を開発しています。これにより、広範囲にわたって崖の異常を安全な場所から迅速に監視できるようになります。これまでの研究により、崖のどこに異常（変形）があり、その変形が進んでいるかどうか知ることができるようになりました。現在は、検知された変形状況から、いつ頃崖崩れが発生しそうか予測する方法について研究を進めています。このほか、土砂災害時の救助活動の事例を集め、行方不明者がいそうな場所を推定する方法について研究する計画です。

In Japan, some 50 people on average lose their lives each year in landslides and other types of slope-related disasters, which are a major form of natural disaster. The prevention of secondary disasters should be the major focus when conducting rescue efforts in areas around landslide disaster sites. At present, the visual monitoring of slopes by the eye is the main method used, but this is problematic in many ways due to the limited area of visibility at night, declining attentiveness of human monitors over long periods, and difficulty in detecting gradual changes, for example.

In response, we are developing a technique for remotely detecting slope deformations using a laser scanner instead of visual monitoring. This technique will allow for the rapid monitoring of slope abnormalities over a

■自然斜面の崩壊実験でレーザースキャナによって観測された斜面の変形
Slope deformation observed using a laser scanner in collapse test on a natural slope





離れた場所から崖の変形をリアルタイムに監視する。
This system remotely monitors slope deformation in real time.

wide area from a safe location. Through our research thus far, we have become able to detect where abnormalities (deformation) exist on a slope and whether the deformation in question is progressing. We are now conducting research on a method to forecast when a landslide is likely to occur, based on the detected deformation. Also, we plan on collecting case studies of rescue efforts during landslide disasters to do research on methods of estimating where missing people are likely to be found.

防災情報を、正しくもれなく周知する。
Accurate and thorough dissemination of disaster information

大規模災害発生時に、各個人が自分自身、家族、地域の安全確保のために的確な行動をとるには、被害情報や行政による災害対策情報など、さまざまな防災情報が不可欠です。現在、これらの情報を住民に伝達する手段として、防災行政無線により屋外スピーカーや個別受信機を使って音声放送を行う方法が広く用いられています。しかし、騒音や受信機との距離によっては、聞き返しや聞きまちがいのおそれがあります。また、情報の保存や再確認ができない、難聴者に伝わりにくいなどさらに改善できる点もあります。

そこでわたしたちは、防災行政無線の現状を分析して、誤解のない、理解しやすい防災情報の伝達方法を研究し、その成果を「住民提示用防災情報文章データベース」という形にまとめています。たとえば、橋が渡れないという情報を伝えるのでも、「A橋、B橋、C橋は通行できません。」と言うよりも、「渡ることのできない橋があります。」と、まず大きな情報を伝えた後に、「通行できない橋は、A橋、B橋、C橋です。」と言ったほうが、聞き逃しが少なくなり、情報が伝わりやすくなると考えられます。

またわたしたちは、自力で避難できない方や聴覚に障害のある方のための火災警報通報装置を開発してきました。現在、この装置を火災だけでなく、防災情報全般の受信端末装置として使えるよう研究開発を行っています。さらに、聴覚だけではなく、そのほかの障害を持つ方々のために、ベル、サイレンなどの「音」に加えて、「振動」「光」「におい」などを警報伝達の手段として使うための研究開発も進めています。

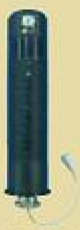
聴覚に障害のある方のための火災警報通報装置
Fire alarm notification system for the hearing impaired

When a large-scale disaster strikes, obtaining many types of disaster information, such as that on damage and disaster countermeasures from the government, is indispensable for enabling individuals to take appropriate action to ensure their safety and that of their families and locality. At present, outdoor speakers connected to the government's disaster-prevention administration radio system and voice broadcasts using individual receivers are the most widely used methods of transmitting such information to the residents of a disaster hit area. However, noise and the distance from receivers may result in information not being heard or being misheard. Such methods have room for improvement because they do not allow residents to save or double-check the information and can make it difficult for information to be conveyed to the hearing impaired.

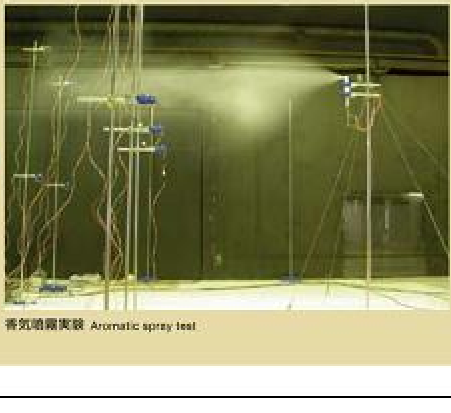
In response, we are analyzing the current state of the disaster-prevention administration radio system and researching ways to convey disaster information in an accurate and easy-to-understand way. The fruits of our efforts are being collected in the form of a disaster prevention information and document database for residents. For example, when making an announcement about some bridges that cannot be crossed, it would be easier for listeners to understand "there are bridges that cannot be crossed" and then adding the more detailed message "the bridges that are out of service are bridge A, bridge B, and bridge C," instead of saying only, "Bridge A, bridge B, and bridge C are out of service."

We have also developed a fire alarm notification system for those who cannot evacuate on their own and the hearing impaired. At present, we are conducting R&D on making the system available as a receiving terminal system for not only fires, but for other disasters, as well. We are also involved in R&D on alternative means of warning not only the hearing impaired, but also those with other impairments, by means of vibration, light, and smell, in addition to conventional audible means such as bells and sirens.

「におい」を使った警報伝達のための実験
Fire alarm test using smell



香気発生装置
Scent generator



香気噴霧実験 Aromatic spray test

020

災害に対応する、自治体の意思決定支援。

Supporting decision-maker in local governments for responding to disasters

021

地震など大規模災害発生時、市町村の災害対策本部は非常に多くの応急対策を行なわなければなりません。このような場合、どのような対策を、いつ、どのように実施するべきか的確に判断することは、極めて難しいことです。また、必要とされる対策や優先順位は、発災期→避難誘導期→避難生活期と、災害発生から時間とともに変化します。そのため、災害対策本部における的確な意思決定には、その時々の正確な状況把握が必要です。このような困難な状況の下でも、自治体が合理的な災害対応にあたれるようにするため、わたしたちは、災害対策本部の業務を情報面から支援するための研究開発を行っています。

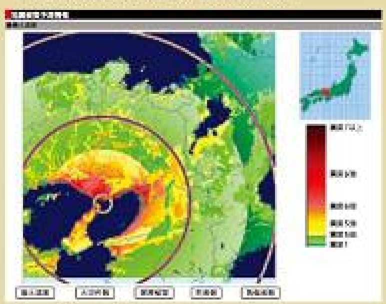
災害対策本部の業務は、「状況把握」「意思決定」「対策実施」の3つのプロセスの繰り返しです。わたしたちは、「状況把握」を支援するためのツールとして、地震発生直後の実被害情報の空白を埋めるための「リアルタイム地震被害想定システム」や被害情報を効率的に収集するための情報収集端末、さらに輻輳（ふくそう）に巻き込まれず確実な情報伝達を可能にする通信システムの開発を行っています。また、「意思決定」を支援する情報システムとして、応急対応に必要な資機材の量などを算出する「応急対応需要算出システム」、時々刻々変化する状況のなかにあっても、合理的な「意思決定」や確実で効率的な「対策実施」を行えるようにするための「応急対応支援システム」の開発を行っています。

In a large-scale disaster, such as an earthquake, the disaster prevention headquarters of the affected municipalities must undertake an extremely large number of emergency measures. However, it is extremely difficult to accurately decide when and how specific measures should be implemented under such circumstances. Moreover, the necessary measures and their order of priority vary over time according to the disaster period, evacuation guidance period, and the post-evacuation period. This necessitates a proper understanding of changing circumstances so that accurate decision making can be carried out at the disaster prevention headquarters. To enable local governments to rationally respond to disasters, even under such difficult circumstances, we are conducting R&D on supporting the tasks performed by disaster prevention headquarters.

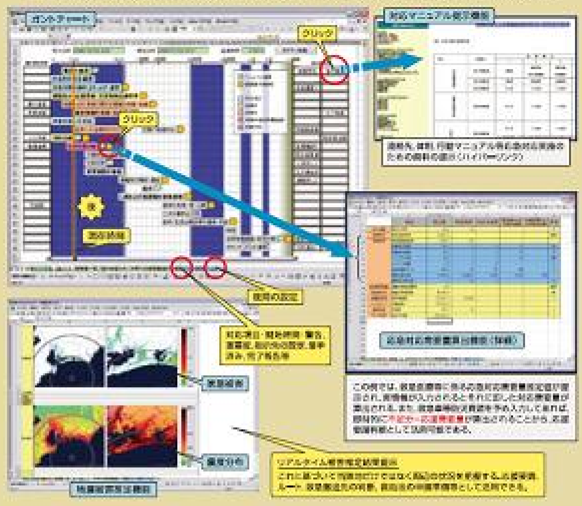
The tasks carried out at disaster prevention headquarters involve a cycle of three processes: disaster assessment, decision-making and measure implementation. As a means of supporting the disaster assessment, we are developing a real time earthquake damage estimation system to fill in the gaps in actual damage information immediately after an earthquake strikes, information collection terminals for efficiently gathering damage information, and a communications system that can reliably transmit information without congestion. To support decision-making, we are developing an emergency response demand calculation system. This system can calculate the amount of resources necessary for a particular emergency response.

In addition, we are also developing an emergency response support system for rational decision-making, and the accurate and efficient implementation of measures, even under circumstances that are changing by the hour.

■リアルタイム地震被害想定システム
Real time earthquake damage estimation system



■応急対応支援システム
Emergency response support system for decision making at disaster prevention headquaters



研究紹介
Research
5

特殊災害に対する安全確保

Ensuring safety against special disasters

消防隊員の地下鉄サリン事件における被災や、JCO核燃料加工施設での臨界事故による放射線被ばく、三重県のゴミ固形化燃料（RDF）施設火災での殉職など、「特殊災害」で消防隊員が犠牲になっています。消防隊員は、前例や経験のない未知の火災や災害にも迅速に駆けつけ、災害の拡大防止・火災の早期鎮圧・救助に努めなければなりません。特殊災害による被害を減らすためには、消防隊員自身の被災を防ぎ、効果的な消防活動を可能にする技術を開発することが不可欠です。わたしたちは、特殊災害が発生した際、消防活動を始める前に災害状況を把握するための手法を開発したり、高度な消火技術を確立したりするための研究を行っています。また、消防隊員の安全を確保し負担を軽減できるよう、消防活動支援ロボットや救助資機材の開発も進めています。

Firefighters' lives have been sacrificed by "special disasters," including the subway sarin gas attack on the Tokyo subway system, the criticality accident at the JCO uranium processing plant, and the fire at the refused-derived fuel (RDF) plant in Mie Prefecture. Firefighters must rush to emergency situations, including fires and disasters that are unprecedented or unfamiliar, to prevent further damage and casualties, control fires as soon as possible, and engage in rescue efforts. Developing technology that can protect firefighters and aid effective firefighting efforts is indispensable for reducing the damage inflicted by special types of disasters. We are developing techniques for comprehending the state of damage in a disaster hit area before firefighting begins and are conducting research on establishing advanced extinguishing technology in the event of special types of disasters. We are also developing firefighting support robots, and rescue equipment and materials to ensure the safety of firefighters, and reduce the burden on them.

原子力発電所における、消防技術の確立。

Establishing firefighting technology at nuclear power plants

原子力発電所では、放射性物質を封じ込めるために、強制換気によって負圧の状態に保たれています。また原子力発電所には、危険物・可燃性気体・高温高圧の水蒸気を取り扱う施設と大容量の電気設備が共存しています。2004年の福井県における原子力発電所の事故では、二次冷却水配管の破断によってなかの熱水が高温の水蒸気となって噴出したことにより、5人の方が亡くなりました。また、2006年には、福井県にある原子力発電所の放射性廃棄物の処理を行う建屋内で火災がありました。

わたしたちは、このような強制換気空間という特殊な環境下における火災の性状・挙動を明らかにするための研究を行っています。これらの研究結果にもとづいて、原子力発電所における消防活動上の注意点をまとめ、火災対応訓練で使用するためのガイドラインを作成する計画です。

Negative pressure is maintained by forced ventilation systems in nuclear power plants to prevent leakages of radioactive substances. Nuclear power plants also have a mix of facilities that handle hazardous materials, flammable gases, and high-temperature/high-pressure steam, as well as massive electrical facilities. The 2004 accident at the nuclear power plant in Fukui Prefecture resulted in five fatalities due to high temperature steam shooting out of a secondary cooling pipe that ruptured. Also, in 2006, there was a fire in a radioactive waste processing building at a nuclear power plant in Fukui Prefecture.

We are conducting research to shed light on the nature and behavior of fires that occur in special environments with forced ventilation. We plan on using our research results to draw up a list of precautions for fighting fires at nuclear power plants and create guidelines for use in fire-response training.

2004年 福井県にある原子力発電所で発生した二次冷却水配管の破断事故
2004 accident caused by the rupture of a secondary cooling pipe at a nuclear power plant in Fukui Prefecture

■2006年 福井県における原子力発電所火災
2006 Nuclear power plant fire in Fukui Prefecture

1・2：出火場所（廃棄物処理建屋内）　3：火災による煙層の跡が壁に残っている
4：すすが堆積した廊下
1・2：Where fire started (inside a waste material processing building)
3：The wall shows smoke layer　4：Corridor covered in soot

022

リサイクル資源化施設の爆発対策。
Explosion countermeasures at recycling plants

　リサイクル資源化施設は、しばしば爆発事故を引き起こしています。2003年に三重県のゴミ固形化燃料（RDF）発電所で発生したRDF貯蔵槽の爆発事故では、飛散物によって消防隊員が殉職しました。このような痛ましい事故をなくすために、わたしたちは、RDF貯蔵時の爆発火災の消火方法と、爆発災害による被害を軽減するための方法を研究・開発しています。

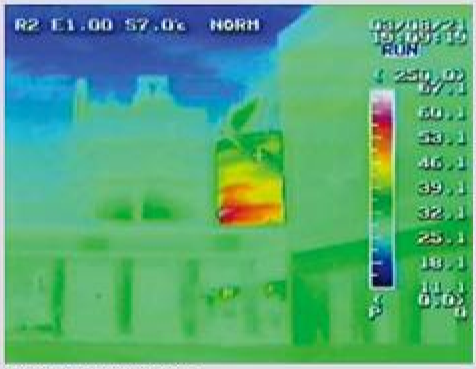
　これらの研究の一環として、リサイクル資源化施設においてリサイクル対象物質を大量に集積したり加熱したりした場合、どのような危険性が潜んでいるのかを明らかにするために、可燃性混合気体がプラント内でどのように生成され、万一それが爆発した場合にプラント本体がどのような力を受けるのか検討を重ねています。この検討結果を、リサイクル資源化施設の異常事象の事例と比較することで、想定される破壊現象とその影響のおよぶ範囲をおおむね予測することが可能になります。これらの研究に基づき、消防活動上のリスクを低減するための注意点をまとめる計画です。

RDF-5
（可燃廃棄物を粉砕し圧縮して成形したもの）
RDF-5 (created by crushing flammable refuse and then pressure forming it)

2003年 三重県のごみ固形化燃料（RDF）発電所で発生したRDF貯蔵槽の爆発事故
2003 explosion of an RDF storage silo at a refuse-derived fuel (RDF) power plant in Mie Prefecture

Explosions frequently occur at recycling plants. The 2003 explosion of the refuse-derived fuel (RDF) storage silo that occurred at the RDF power plant in Mie Prefecture sent deadly debris flying through the air, killing two firefighters. We are conducting R&D on methods for extinguishing fires in RDF storage silos and methods for reducing the damage from explosions, so that such heart-breaking accidents will never happen again.

As part of this research, we are attempting to shed light on the hidden hazards inherent in the accumulation or heating of massive amounts of recyclable materials at recycling plants. This includes continual studies on how flammable gas mixtures are generated within such plants, and in the event that they explode, what sort of forces the plant itself would be exposed to. By comparing the results of these studies to case studies of abnormal events at recycling plants, we will be able to make general prediction on destructive phenomena and the extent of their effects. We plan on using this research to draw up a list of precautions for reducing the risks associated with firefighting efforts.



炎上中のRDF貯蔵槽の赤外画像
Infrared image of the burning RDF storage silo

屋内型リサイクル資源化施設内で発生した火災を想定して行った消火実験
「二流体ノズル」を使用して消火している。
Extinguishing test performed on a hypothetical fire at an indoor waste processing plant
The fire is being extinguished using a dual fluid nozzle.

研究成果を基に実用化したロボット
可燃性ガス・有毒ガス等を検出して危険を知らせる。
An actual fire-department reconnaissance robot
The robot was developed based on research results.
It detects flammable or poisonous gas and warns of such risks.

消防活動を支援する、ロボット技術・救助資機材の開発。

Developing robot technology and rescue equipment that supports firefighting efforts

原子力施設における事故やテロによる災害などでは、消防活動を行う消防隊員自身が危険にさらされることになります。このような危険な状況のなかで、ロボットは消防隊員の代わりを務めることでその威力を発揮します。わたしたちは、消防隊員の安全を確保し、負担を軽減するために、消防活動支援ロボットシステムを開発しています。これまでに、はしご車では届かない高層ビルを自ら登ることのできる昇降ロボットや、JCO臨界事故のような原子力関連施設における事故発生時に、避難できない人を被ばくから守る防護壁ロボットなどを開発してきました。

現在は、カルガモの親子のように消防隊員に追従して移動し、移動した経路を記憶することができるロボットを開発しています。このロボット一台一台は小さなロボットですが、複数台のロボットが力を合わせて、消防隊員が救助した人を自動的に安全な場所まで搬送することができます。また資材搬送や撤収時の先導などにもその威力を発揮します。

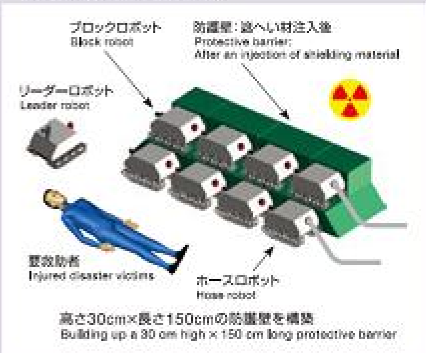
使用するロボットのベースは、わたしたちがこれまでに開発した「FRIGO」シリーズです。「FRIGO」シリーズには、研究用の拡張性を重視した「FRIGO-R」と、実用機への応用性を重視した「FRIGO-D」があります。「FRIGO-D」については、実用化を進めるために、防水・防塵・防爆・耐衝撃性の向上を図る計画です。また、各消防本部と連携しながら、実践配備へ向けた検討も行っています。

Firefighters are exposed to risk when they attempt to fight fires and rescue at the site of a nuclear accident or terror strikes. Robots can prove useful in replacing firefighters in such dangerous situations. We are developing a robot system for supporting firefighting efforts to ensure the safety of firefighters and reduce the burden on them. We have thus far developed a ladder robot that can climb up and down high-rise buildings that are unreachable with ladder trucks, and a robotic wall system that protects victims from radiation during accidents such as the criticality accident that occurred at the JCO uranium processing facility.

We are now developing robots that move behind firefighters, like ducklings following their mother, and memorize the route along which they move. The robots are small in size, but each one will be used by firefighters to automatically transport people they rescue to a safe place. They will also prove useful in transporting materials and guiding firefighters when they retreat from the site.

The base module we are using for the robot is the FRIGO series that we developed. The FRIGO series consists of FRIGO-R, which is oriented toward expandability for research purposes, and FRIGO-D, which is oriented toward practical applications for actual robots. We are planning to expand the practical applications for FRIGO-D by improving its water, dust, explosion, and impact resistance. We are also conducting studies on coordinating with various firefighting headquarters and deploying the robots in actual practice runs.

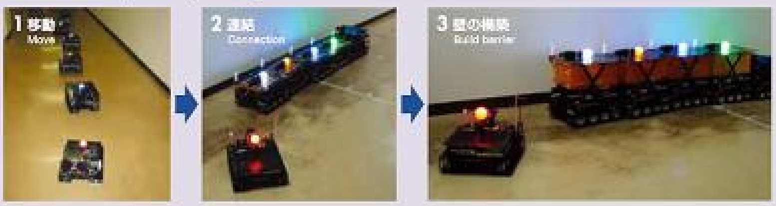
■防護壁ロボットのコンセプト
Concept of the robotic wall system



■要救助者搬送ロボットのイメージ
Robots carrying injured disaster victims

移動する人を自動的に
追いかけていくロボット
A robot that follows a person
around automatically

■リーダーロボットのみの操縦ですべての動作を実現
All actions are implemented by controlling the leader robot



移動経路を記憶して、
自動的に戻れるロボット
A robot that can memorize the route
it took and automatically return

二、日本撒水幕檢測試驗報告

財団法人建材試験センター

平成１２年６月　１日制定
平成２２年６月　１日変更版

防耐火性能試験・評価業務方法書

「防火設備の性能評価（遮炎性能）」

に関する抜粋版

この抜粋版における、該当法令等は次のとおりです。

該当法令	構造・材料等	業務方法書での試験・評価方法
法第2条第9号の2のロ	防火戸その他の防火設備	4.9 遮炎・準遮炎性能試験・評価方法
法第64条	外壁の開口部の防火設備	4.9 遮炎・準遮炎性能試験・評価方法
令第112条第1項	特定防火設備	4.9 遮炎・準遮炎性能試験・評価方法
令第114条第5項	準耐火構造の界壁、間仕切壁及び隔壁に用いる防火設備	4.9 遮炎・準遮炎性能試験・評価方法

ＪＴＣＣＭ
平成１２年　６月　１日制定
平成１３年　８月　２日変更（い）
平成１３年１２月　７日変更（ろ）
平成１５年　７月１４日変更（は）
平成１６年１０月１８日変更（に）
平成１７年　７月１１日変更（ほ）
平成２２年　６月　１日変更（へ）

防耐火性能試験・評価業務方法書

目　次

１．評価業務の範囲

本業務は、次の(1)から(20)までの規定に基づく認定に係る評価について適用する。（ろ）

(1) 法第２条第７号
(2) 法第２条第７号の２
(3) 法第２条第８号
(4) 法第２条第９号の２ロ
(5) 法第23条
(6) 法第64条
(7) 令第70条
(8) 令第109条の３第１号
(9) 令第109条の３第２号ハ
(10)令第112条第１項
(11)令第113条第１項第３号
(12)令第114条第５項
(13)令第115条の２第１項第４号
(14)令第115条の２の２第１項第１号
(15)令第115条の２の２第１項第４号ハ
(16)法第２条第９号(ろ)
(17)令第１条第５号(ろ)
(18)令第１条第６号(ろ)
(19)法第22条第１項(ろ)
(20)法第63条(ろ)

２．評価申請のための必要図書

性能評価を申請するために必要な図書は次のとおりとする。様式その他については別に定めるものとする。

(1) 性能評価申請書
(2) 構造説明図
(3) 構成材料等の仕様
(4) 施工方法（ろ）
(5) 申請仕様範囲の説明
(6) 申請会社等の概要
(7) その他

３．評価方法

評価は次に定める方法により行うものとする。

(1) 評価員は、表１に示す性能評価の区分ごとに、４に定める試験・評価方法及び２に定める提出図書に基づき評価を行う。

(2) 性能評価のための試験は、原則として、財団法人建材試験センター中央試験所又は西日本試験所の施設及び設備を用いて実施する。ただし、水幕によって炎を遮る防火設備及び幅が３．８ｍを超える試験体または高さが３．６ｍを超える試験体の防火設備の遮炎・準遮炎性能試験については、独立行政法人建築研究所の施設及び設備を用いて実施することができる。(ほ)

(3) 評価員は、評価上必要があるときは、２に定める提出図書について申請者に説明を求めるものとする。

(4) 評価員は、財団法人建材試験センターが既に認定のための審査に当たって行った評価に係る試験の結果を用いることにより、新たな試験を要さずに評価を行うことができる。(ほ)

表１　性能評価の区分及び方法

省令第59条の規定に係る区分	法及び政令の規定による区分		防耐火性能の試験・評価方法
	該　当　法　令	構造、材料等	
１号	法第2条第7号	耐火構造	耐火性能試験・評価方法
	法第2条第7号の2	準耐火構造	準耐火性能試験・評価方法
	法第2条第8号	防火構造	防火性能試験・評価方法
	法第2条第9号の2のロ	防火戸その他の防火設備	遮炎・準遮炎性能試験・評価方法
	法第23条	準防火構造	準防火性能試験・評価方法
	法第64条	外壁の開口部の防火設備	遮炎・準遮炎性能試験・評価方法
	令第70条	柱の防火被覆	柱防火性能試験・評価方法
	令第109条の3第1号	準耐火建築物と同等の耐火性能を有する建築物の屋根	屋根遮炎性能試験・評価方法
	令第109条の3第2号ハ	準耐火建築物と同等の耐火性能を有する建築物の床及び直下の天井	床防火性能試験・評価方法
	令第112条第1項	特定防火設備	遮炎・準遮炎性能試験・評価方法
	令第113条第1項第3号	防火壁を設けた部分の屋根	屋根遮炎性能試験・評価方法
	令第114条第5項	準耐火構造の界壁、間仕切壁及び隔壁に用いる防火設備	遮炎・準遮炎性能試験・評価方法
	令第115条の2第1項第4号	防火壁の設置を要しない建築物の床	床防火性能試験・評価方法
	令第115条の2の2第1項第1号	耐火建築物とすることを要しない特殊建築物の主要構造部	準耐火性能試験・評価方法
	令第115条の2の2第1項第4号ハ	耐火建築物とすることを要しない特殊建築物のひさし等	ひさし等遮炎性能試験・評価方法
	令第129条の2の5第1項第7号ハ	防火区画等を貫通する管等	（業務方法書対象外）（ろ）
２号	法第2条第9号	不燃材料	不燃性能試験・評価方法
	令第1条第5号	準不燃材料	準不燃性能試験・評価方法
	令第1条第6号	難燃材料	難燃性能試験・評価方法
３号	法第22条第1項	通常火災を想定した屋根の構造	屋根葺き材の飛び火性能試験・評価方法
	法第63条	市街地火災を想定した屋根の構造	屋根葺き材の飛び火性能試験・評価方法

４．９　遮炎・準遮炎性能試験・評価方法

建築基準法第２条第９号の二のロ(防火戸その他の政令で定める防火設備)、建築基準法第６４条(外壁の開口部の防火設備)、建築基準法施行令第１１２条第１項(防火区画に用いる特定防火設備)、建築基準法施行令第１１４条第５項(準耐火構造の界壁、間仕切壁及び隔壁に用いる防火設備)の規定に基づく認定に係る性能評価は、次に掲げる試験・評価方法により行う。

４．９．１　防火設備性能試験・評価

１．総則

（１）防火設備の遮炎・準遮炎性能試験(以下、防火設備性能試験という)は２に規定する試験体を、３に規定する試験装置によって、４に規定する試験条件を与えて、５に規定する測定を行い、その測定値が６に規定する判定基準を満足した場合に合格とする。

（２）防火設備性能試験は、防火戸その他の防火設備に適用する。

（３）防火設備性能試験は、火災時において同時に火炎を受けると認められる面について行うものとする。ただし、申請仕様が複数ある場合、性能評価機関において別途実施した防火設備性能試験の結果に基づき、その仕様が試験を実施する仕様と同等以上の遮炎性能を有すると明らかに認められる場合においては、その仕様についての試験を省略することができる。なお、法６４条の準遮炎性能の要求については屋外面について試験を実施する。

２．試験体

（１）試験体の材料及び構成は、原則として、実際のものと同一とする。ただし、遮炎性を有することが予め確認されている部分並びに明らかに遮炎性の確保に寄与しない部分は、試験体から取り除くことができる。また、実際のものに複数の仕様がある場合は、次のイからホによるものとする。(に)

イ．表面に施した溝加工等による断面欠損に複数の仕様がある場合は、欠損部容積の合計が最も大きい仕様を試験体とする。

ロ．表面化粧層の組成・構成に複数の仕様がある場合には、有機化合物（以下、「有機質」という）の合計質量が最も多い仕様を試験体とする。

ハ．新聞受け(郵便口)、ドアアイ、がらり、換気小窓等の付属品がある場合は、付属品のある仕様の試験体とする。

ニ．戸の寸法及びガラスの寸法が相似的に変わる仕様がある場合は、最大寸法の仕様の試験体とする。

ホ．水幕によって炎を遮る防火設備において、放水圧力の仕様に範囲がある場合については、最低放水圧力となる仕様を試験体とする。(に)

（２）試験体の個数は、原則として、加熱を受ける面（以下、加熱面という。）ごとに１体とする。ただし、加熱面が１面のみの場合はその面について試験を２体実施する。(に)

（３）遮炎性の検証を必要とする部分が非常に大きいために試験体の形状及び大きさを実際のものと同一とすることが極めて困難な場合においては、その形状を、幅3000mm以上、高さ3000mm以上、厚さは実際によるものとすることができる。ただし、この場合においては、試験によって得られた結果から、評価しようとする仕様の性能を充分に検証できることが明らかにされていなければならない。(に)

また、加熱面は、原則として試験体の全面とするが、水幕によって炎を遮る防火設備にあっ

ては、試験体に設けられた幅2500mm以上、高さ1500mm以上の開口部とすることができる。(に)
(４) 試験体は、原則として気乾状態に乾燥したものとする。ここで、気乾状態とは、構成材料の含水率が木材にあっては15%以下、せっこう等の結晶水を持つ材料にあっては、40℃において恒量になるまで乾燥して求めた場合の値が２%以下、その他の材料にあっては５%以下である。ただし、室内において含水率がほぼ一定の平衡状態となることが確認される場合、火災時において常に湿潤状態が保たれることが明白であるもの（水幕を利用するものを含む）は、この限りでない。(に)
(５) 試験体は、原則として戸、枠及び(6)に規定する周壁を含めて作製し、部分により遮炎性能上の弱点があると認められる場合においては、当該部分が試験体に含まれるようにすること。遮炎性能上の弱点と認められる部分は、引き戸構造の戸袋部分、新聞受け（郵便口)、ドアアイ、ドアクローザ、がらり、錠前及び換気小窓等とする。ただし、水幕によって炎を遮る防火設備にあっては、試験体は開口部を有するマスク、散水ノズル、給水配管、熱電対等を一体的に配置した散水ボックスとし、弱点部は散水密度の低い部分（遮炎能力のあるたれ壁等で防御されている部分を除く。）とし、性能評価の申請に先立って、散水密度の低い部分を見極める試験を実施しておくこととする。(に)
(６) 試験体の周囲100mm以上の周壁仕様は、標準施工仕様とする。ただし、標準施工仕様に湿式工法（モルタル等）及び乾式工法（繊維混入けい酸ｶﾙｼｳﾑ板張り等）の両方ある場合は乾式工法により試験を実施する。また、周壁の工法が特定できない場合は、原則として、次の標準試験体周壁を用いる。(に)

標準試験体周壁の仕様（木造軸組工法）
① 特定防火設備　：繊維混入けい酸ｶﾙｼｳﾑ板（厚さ12mm）の２枚重ね張り又は
　　　　　　　　　繊維混入けい酸ｶﾙｼｳﾑ板（厚さ25mm）単板張り
② 防火設備　　　：せっこうボード（厚さ12.5mm）の２枚重ね張り

ただし、水幕によって炎を遮る防火設備にあっては、繊維混入けい酸ｶﾙｼｳﾑ板（厚さ10mm）とする。(に)
(７) 既存の試験ないしは計算結果から、各仕様の間での防火上の有利不利が判断できる場合には、もっとも防火上不利となる仕様を試験体とすることができる。(ろ)

３．試験装置
(１) 加熱炉は、４に規定される温度の時間的変化を試験面の全面にほぼ一様に与えられるようなものとする。
(２) 加熱炉は、試験体の片面を加熱できる構造のものとする。
(３) 炉内温度を測定するための熱電対（以下、「炉内熱電対」という）の熱接点を９個以上、試験面に均等に配置し、試験体から100mm離れた位置に設置する。ただし、防火ダンパー等の試験面の面積が非常に小さい場合にあっては、炉内熱電対の熱接点の数を１ないし２個に減ずることができる。また、水幕によって炎を遮る防火設備にあっては、加熱面に位置する熱電対について、水の影響を受けることがないように、1000mm離れた位置とすることができる。(に)
(４) 加熱炉は、炉内圧力を測定する装置を備えているものとする。

４．試験条件

（1）加熱等級は、加熱時間に応じて20分加熱、45分加熱及び60分加熱に区分するものとする。
（2）水幕によって炎を遮る防火設備以外にあっては、炉内熱電対によって測定した温度（以下、「加熱温度」という）の時間経過が、許容誤差内で次の式で表される数値となるように加熱する。(に)

$$T = 345\log_{10}(8t + 1) + 20$$

この式において、Tは平均炉内温度（℃）、tは試験の経過時間（分）とする。

加熱温度の許容誤差は次の値とする。ただし、大量の可燃材料を含む試験体については、可燃材料が突然着火したことにより平均炉内温度を増加させたことが明らかに確認された場合はこの限りでない。

a）　5＜t≦10　de≦15(%)　　b）10＜t≦30　de＝{15-0.5(t-10)}(%)

c）30＜t≦60　de＝{5-0.083(t-30)}(%)

ここで　de=100(A-As)/As

Aは実際の平均炉内温度時間曲線下の面積、Asは標準時間温度曲線下の面積、tは試験の経過時間（分）とする。

a)に対しては１分を超えない間隔、b)及びc)に対しては５分を超えない間隔で合計し面積を算定する。

（3）水幕によって炎を遮る防火設備にあっては、各加熱等級毎に５分間、以下の温度を保持するものとする。(に)

２０分加熱：781℃以上（に）

４５分加熱：902℃以上（に）

６０分加熱：945℃以上（に）

（4）水幕によって炎を遮る防火設備以外における、試験面の圧力は、次のイからハによるものとする。(に)

イ．加熱炉内の高さ方向の圧力勾配は、1000mmの高さ当り平均８Paとする。

ロ．試験面の圧力の誤差は、試験開始から５分までに±５Paとなり、試験開始から10分までに±３Paとなるように調整する。

ハ．試験面の圧力は、試験体下端から500mmの高さで０となるような勾配を有するものとする。ただし、試験体の上端で20Paを超えないように中立軸高さを調整する。防火ダンパー等のように試験面の面積が小さい場合にあっては、試験面前面に20Paを超えない正圧がかかるように調整する。(ろ)

（5）水幕によって炎を遮る防火設備における加熱面の圧力は、加熱面全体の半分以上で正圧となるようにする。(に)

５．測定

（1）　温度の測定は、１分以内ごとに行うものとする。

（2）　水幕によって炎を遮る防火設備以外にあっては、非加熱面での火炎及び火炎が通る亀裂等の発生の有無について目視観察する。ここで、火炎が通る亀裂等とは、これらを通して、火炎が非加熱面へ出てくるか、又は加熱炉内が目視できるものをいう（以下、同じ)。(に)

（3）　水幕によって炎を遮る防火設備にあっては、次のイからニに定めるところにより裏面温度の測定を行うものとする。(に)

イ．裏面温度の測定は、防火設備の加熱面の反対面（防火設備の厚さは申請に基づくものとするが、測定に当たっては水の影響を受けないようにする。）で行う。(に)

ロ、裏面温度の測定は、固定熱電対により行う。(に)

ハ、固定熱電対の熱接点は、防火設備の加熱面の反対面に５ヶ所以上均等に配置するものとする。(に)

ニ、裏面温度の測定は、１分以内毎に行う。(に)

６．判定

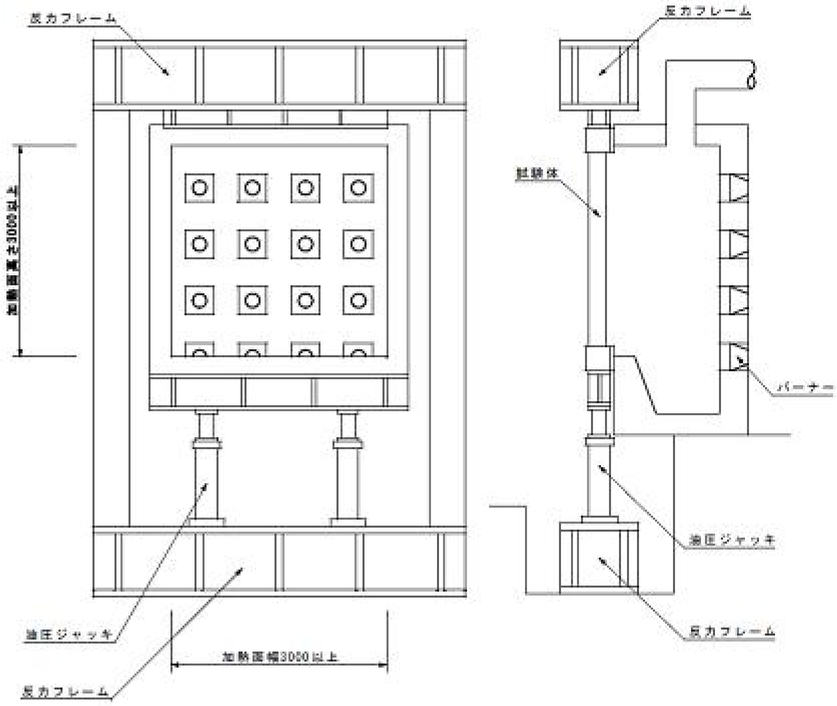
水幕によって炎を遮る防火設備以外にあっては、各試験体について実施した加熱試験によって得られた測定値が、次のイからハの基準を満足する場合に合格とする。(に)

イ、非加熱側へ１０秒を超えて継続する火炎の噴出がないこと。

ロ、非加熱面で１０秒を超えて継続する発炎がないこと。

ハ、火炎が通る亀裂等の損傷及び隙間を生じないこと。ただし、防火戸の沓ずり及びシャッターの床に接する部分のすき間(10mm以下)は除外する。

水幕によって炎を遮る防火設備にあっては、加熱時間中の裏面温度が、最高で200℃以下、平均で160℃以下であって、各加熱等級（２０分、４５分、６０分）に対応した時間、所定の水幕を形成できることが明らかな場合に合格とする。(に)



壁用試験装置図（寸法単位：mm）

５．性能評価書

性能評価書は、次の項目について記述したものとする。様式その他については別に定めるものとする。

（１）評価機関名、評価番号、評価完了年月日

（２）性能評価の区分

（３）評価報告(試験結果の概要、考察、評価のまとめ)

（４）申請者名(会社名、代表者名)（ほ）

（５）件名(構造方法又は建築材料の名称)

（６）構造説明図(別添)

（７）構成材料等の仕様(別添)

（８）施工方法(別添)（ろ）

（９）〔削除〕（へ）

三、日本撒水幕檢測試驗與水系統結合耐火構件耐檢測實驗

期刊論文

水幕を用いた防火設備の性能評価

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水幕　防火設備　遮炎性能
遮熱性能　性能評価

1．はじめに

災害時の人命安全の確保の観点より新たな技術開発及び普及が望まれる。このたび，建築基準法施行令第112条第1項（防火区画に用いる特定防火設備）の規定に基づく構造として，水幕によって炎を遮る防火設備についての試験方法ならびに評価方法を検討したので報告する。

水幕という従来の固定の区画ではなく水の流れが伴った防火設備を評価するために，加熱炉を用いた性能評価試験に至るまで各種の予備試験を実施したものである。

2．試験体

水幕を形成している部分（以下，「WS（ウォータースクリーン）」とする。）と，WSの形成に必要な水噴霧ヘッド，加圧水を輸送する配管及び管継手，水を加圧送水する加圧送水装置（ポンプ），水源が主たる装置となる。今回試験を行ったWSの仕様を表1に示す。

表1　WSの仕様

項　目	1列配置（試験体記号A）	2列配置（試験体記号B）
水噴霧ヘッド配管間隔［mm］	300	500
水噴霧ヘッド配管列間隔［mm］	−	1000
水噴霧ヘッド水圧［MPa］	1.0	0.8
スクリーン厚さ（mm）	1600±250（ヘッドより500位置）	3200±500（ヘッドより500位置）
スクリーン幅（mm）	800～50000	
スクリーン高さ（mm）	1800～6000	
スクリーンの形状	幕状	

3．試験方法

試験の流れとしては，試験1で装置の仕様確認を行い試験2で弱点部の確認，試験3で加熱試験を行った。

（1）試験1

主に，水噴霧ヘッドの仕様確認を行う。安定したWSを形成する上で重要になる水噴霧ヘッドの形状・寸法，質量等を計測し，更にそのヘッドを用いて，決められた水圧に対する放水量及びヘッド近傍の噴射角度を測定し管理値内であることを確認する。

（2）試験2

（財）建材試験センターが定めた「防耐火試験・業務方法書」に，試験体には弱点部が含まれるようにと謳われている。火災時の高温空気層が天井部に出現することを考慮に入れWSを形成し弱点部の確認を行う。水噴霧ヘッドを取り付けた天井面から，50mm，500mm，1000mm，1500mmの垂直位置で，水噴霧ヘッドの真下と，水噴霧ヘッド間水平位置での採水量を比較する（採水試験），また，同様の位置でWSを介しヒーターの人工熱源と熱放射計を用いて受熱量を測定し，熱放射遮断率を比較する（熱放射試験）。更に，目視によりWSの均一性，散水量の偏在箇所（弱点部）を確認すると共に，WSの最大仕様高さ6mでのWSの均一性を確認する（外観観察）。1列配置時の試験状況を写真1に示す。

写真1　試験状況（a：採水試験，b：熱放射試験）

（3）試験3

加熱炉を使用して1列配置及び2列配置での加熱試験を実施し裏面温度の測定結果から，遮熱性能の比較を行う。試験体は，開口部（幅2500mm，高さ1500mm）を有するマスク，散水ノズル，給水管，熱電対等を一体的に配置した散水ボックスにより構成されている。また，WSは試験2で確認された弱点部を含むものとし，業務方法書に従った。加熱は，本防火設備の性状より炉内の温度が945℃以上を5分間維持するように制御し，測定にはK熱電対を先端を封じた保護管に入れ，加熱面から100mm離した位置で測定した。裏面温度の測定は，シース熱電対を用いて測定した。加熱中の炉内圧力は，加熱面全体の半分以上で正圧となるように調整した。また，加熱中のWSの変化について目視により観察した。試験装置の設置状況を写真2に，試験方法を図1に示す。

写真2　試験装置設置状況

Performance Evaluation of Fire Compartment System with Water Screen

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Ichiro NISHIDA

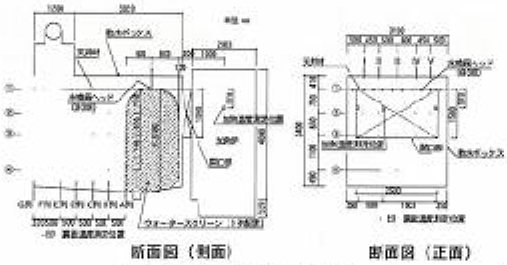

図１　試験方法図（１列配置時）

４．試験結果

（１）試験２

表２の試験結果より，１列配置及び２列配置いずれの結果も天井面近傍の水噴霧ヘッド間に弱点部が出現することを確認した。目視による観察でも同様の結果が得られた。また，高さ６ｍでのＷＳの形成状況は均一に形成されていた。写真３に天井面近傍の弱点部の状況及び高さ６ｍでの形成状況を示す。

表２　試験結果

試験名称及び項目		測定位置 水噴霧ヘッドに対する位置	測定位置 天井面からの位置（mm）	１列配置（試験体記号A）	２列配置（試験体記号B）
放水試験	合計散水量（m/秒）	直下	50	122.3	217.2
			500	26.3	41.9
			1000	41.1	61.2
			1500	50.2	78.8
		間	50	12.2	0.8
			500	35.1	37.4
			1000	41.1	57.7
			1500	41.2	64.9
熱放射試験	熱遮断率（%）	直下	50	93	93
			500	95	92
			1000	86	95
		間	50	77	59
			500	88	95
			1000	86	96

写真３　天井面近傍のＷＳの弱点部（ａ）及び高さ５ｍでのＷＳの状況（ｂ）

（２）試験３

加熱試験結果を表３に示す。この結果より１列配置（水噴霧ヘッド間隔３００mm，水圧１．０ＭＰａ）での方が不利な条件であることを確認した。また，１列配置及び２列配置共に規定値（判定温度）を満足する結果であり最低水圧の確認も行った。温度測定結果の一部を図２に示す，加熱試験では，加熱開始後５分から放水を開始し，放水と同時に裏面温度が急激に下降しＷＳの効果が確認できた。また，１列配置，２列配置共にＷＳを形成する位置から少し離れた天井面の温度が高くなったが，判定温度を下回る結果であり，遮熱性能，遮炎性能を満足する結果であった。

表３　加熱試験結果

項目		１列配置（試験体記号A）	２列配置（試験体記号B）
裏面温度（℃）	最高（規定値）	156 (200)	102 (300)
	平均（規定値）	77 (160)	42 (160)

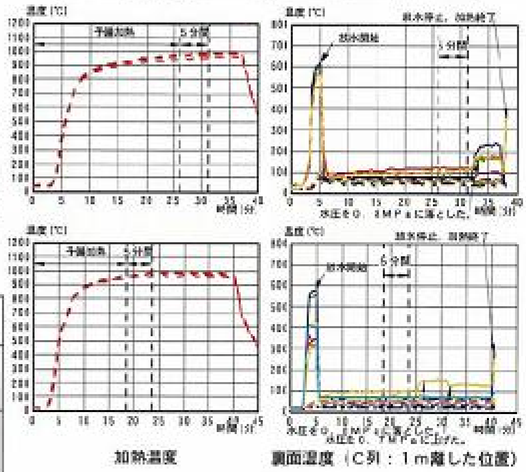

図２　加熱温度及び裏面温度測定結果（上１列配置，下２列配置）

５．まとめ

水幕という水の流れを評価すること，また，水幕形成というシステムの信頼性が要求されることより，以上のように，ＷＳの仕様の確認から始まり，弱点部の確認，加熱試験による不利な試験体の選定という綿密な試験計画を立て，性能評価試験（加熱試験）への実施へとなった。ここでは，評価内容を割愛したが実際の評価内容には本設備の設置場所，水の確保，水の処理等の注意事項が含まれてくる。

最後に，本試験は特殊な試験であるため試験１，試験２に関しては申請者であるホーチキ株式会社の専用設備で，試験３については独立行政法人建築研究所の耐火加熱炉を借用して実施したものである。

《参考文献》

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日本建築学会大会学術講演梗概集
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水膜を用いた防火設備の可能性

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火災安全性能 防火区画 水膜
数値解析 火災実験

1. はじめに

火災時に水を用いた防災システムは、水を利用した消火設備での安全性の歴史から様々な提案がなされている。最近の研究においても、水幕を用いた防火区画の研究、スプリンクラー作動時の火源の挙動研究、木質系材料の表面に水膜を用いた研究などが見られる。火災時、避難・救援活動を行う上で高温の熱曝露の低減という観点からは水膜を形成させた方式は極めて有効な防火設備と考えられる。区画としての可能性を検討する上で、火災実験とともに水膜設備の簡易解析モデルは、火災時に生じている詳細なメカニズムの推定、また、設備の大型化への対応という観点からも不可欠な存在である。今回、水膜を形成させた防火区画に関してその性能を予測するために、定常の簡易解析モデルを構築するとともに、簡単な実験結果と比較を行いその可能性について報告する。

2. 解析モデル

図1に火災時に水膜を形成する方式ならびに解析モデルの概念を示す。シートの両面に流下水によって水膜を形成させる両面方式と高温になる面だけに水膜を形成させる片面方式を対象とした。モデルとしては次の仮定を考えた。

1) 外部からの放射量は水膜に吸収されるものとする。(シート面の効果は無視する。)
2) 形成させる水膜厚さより定常状態とする。
3) 両面方式の場合、両面の流下水は混合し同一厚さ，同一温度とする。
4) 加熱ガスを空気とみなし、水膜と空気の熱移動と物質移動の関係はシュミット数との関係式が成立する。

両面水膜方式おいて、横幅 W〔m〕、縦幅 D〔m〕水流量 $\boldsymbol{m}$〔kg･s^{-1}･m^{-1}〕の水膜部分についての火災時の熱収支式として(1)～(11)式を示す。

$$Q_{Rf} = \varepsilon_f \varepsilon_w \sigma \theta_f^4 WD \quad (1) \qquad Q_{Rn} = \varepsilon_n \varepsilon_w \sigma \theta_n^4 WD \quad (2)$$

$$Q_{Rwi} = 2\varepsilon_w \sigma \theta_{wi}^4 WD \quad (3)$$

$$Q_{Cf} = \alpha_f \left(\theta_f - \theta_{wi}\right) WD \quad (4) \qquad Q_{Cn} = \alpha_n \left(\theta_n - \theta_{wi}\right) WD \quad (5)$$

$$Q_{Pf} = Lk_f \left(X_f - X_{wi}\right) WD \quad (6) \qquad Q_{Pn} = Lk_n \left(X_n - X_{wi}\right) WD \quad (7)$$

$$Q_{mi-1} = C_P \theta_{wi-1} W \dot{m}_{i-1} \quad (8) \qquad Q_{mi} = C_p \theta_{wi} W \dot{m}_i \quad (9)$$

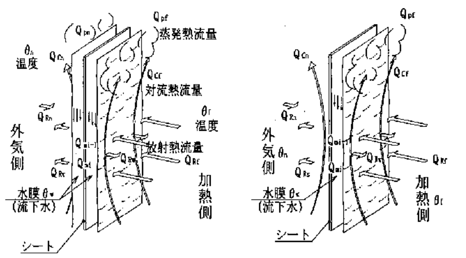
$$Q_{Rf} + Q_{Rn} - Q_{Rwi} + Q_{Cf} + Q_{Cn} + Q_{pf} + Q_{pn} + Q_{mi-1} - Q_{mi} = 0.0 \quad (10)$$

熱移動と物質移動に関してはシュミット数の関係(11)式を用いた。

$$\alpha / k = 1.23 S_C^{0.56} \qquad S_C \approx 0.7 \quad (11)^{1)}$$

<記号> (図1参照)

Q : 熱流量〔W〕 θ : 温度〔K〕
ε_f : 加熱側放射率〔-〕 ε_w : 水の放射(吸収)率〔-〕
ε_n : 外気側放射率〔-〕 α : 熱伝達率〔W･m^{-2}･K^{-1}〕
$\boldsymbol{k}$: 物質移動係数〔kg-蒸気･s^{-1}･m^{-2}〕
σ : ステファン･ボルツマン定数 5.67×10^{-8}〔W･m^{-2}･K^{-4}〕
X : 絶対湿度〔-〕 L : 水の蒸発潜熱〔J･kg^{-1}〕
C_p : 水の比熱〔J･kg^{-1}･K^{-1}〕
添字 f : 火炎及び高温空気塊、n : 外気側周囲、w : 水膜
R : 放射、C : 熱伝達、p : 蒸発、m : 流下水
i : 流水方向分割番号 s : シート



(a)両面水膜方式 (b)片面水膜方式
図1 対象とする水膜方式

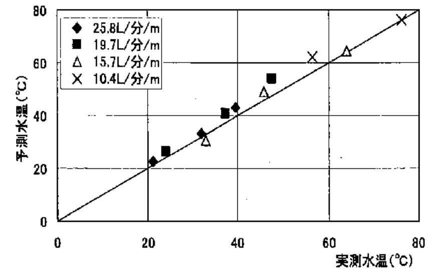


図 2 水膜温度実測値と予測値の比較

3. 計算結果

3. 1 実測結果との比較

高さ1m、幅2mの耐火炉を用いて市販のシートの両面に水膜を形成させ防火区画としての可能性を確認するための基礎データを収集した。

流下水量として 25、20、15、10L/分/m の4水準の実験を行い上部から流下させた外気側の流下水温を横方

Possibility of Fire Prevention Equipment with Water Film

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向に 3 列、高さ方向に 3 箇所の測定を行った。炉内温度の上昇が落ち着いた後、5 分間測定し後半の 3 分間の測定値を平均に用いた。

図 2 は各流下水量の高さ毎の平均の水膜温度実測値と高さ方向に 20 分割した計算結果を比較したものである。両者の関係は比較的良い一致が見られる。図 3 に両面方式ならびに片面方式の流下方向の水膜温度の実験結果と計算結果を示す。横軸に水膜温、縦軸に最下部からの垂直方向の距離をとった。図中の塗りつぶした点はそれぞれの実測平均値である。この図から、流下水量が多いほど水膜温度は低くなっていることがわかる。また、流下水量が多い 25.8L/分/m のケースは、水が流下するとともに温度が直線的に上昇する。一方、流下水量が比較的少ない 10.4L/分/m に関しては高さとともに水温上昇の割合が少なくなっている。

両面方式と片面方式を比較すると、流下水量が多い場合は両者の水温は大きな差異が見られなかったが、流下水量が少なくなるとともに片面方式の水温の方が約 5℃高くなるものと推定される。

3．2　熱移動の割合

図 4 に両面方式での水膜表面での各熱移動成分の割合を示す。(a) 25.8L/分/m の場合、流下水量が大きいため流水による熱移動量が大きく蒸発の割合が 1m の地点でも約 2 割と小さい。(b) 10.4L/分/m の場合のように流下水量が少ない場合、蒸発による熱移動量の割合が流下距離と共に大きくなり、1m の地点では熱移動の割合が蒸発成分で占められていた。蒸発成分は、流下するほど裏面に比べて加熱面の割合が多くなった。

図 5 に両面と片面の両方式の熱移動に占める流下水の割合を示す。両面方式に比較して片面方式(点線)は流下距離が短いうちに流下水の熱移動の割合が高くなる傾向を示した。この原因としては、片面方式の場合、蒸発面積が半分になり加熱量を放出できない分、流水温度を上昇させたものと考えられる。

4．おわりに

水膜を形成させた防火設備の有効性を確認するために簡易な解析モデルを作成しその熱性状を検討した。その結果、両面に水膜を設置する方式が有効であることが判明した。今後は、精緻なモデルでの検討に加えて、火災時における水膜と空気の熱移動と物質移動の関係の把握、散水時の水膜の厚さと均一性もしくは乱れがある場合の耐火性への影響の確認等が残されている。

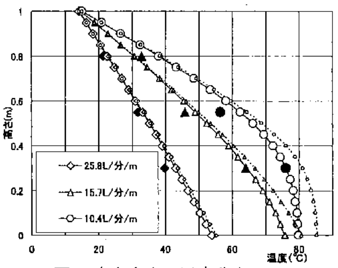

図 3 高さ方向の温度分布

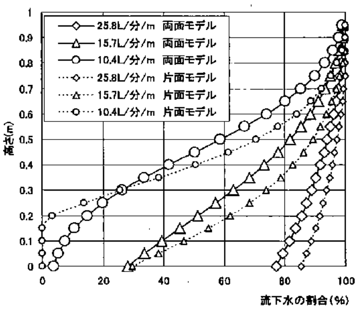

図 5 流下水による熱損失の割合

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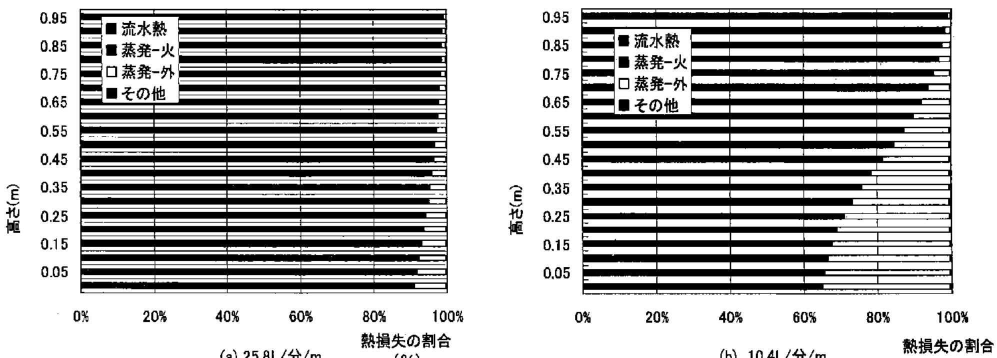
1)　改定 6 版化学工学便覧、化学工学会、丸善、平成 1 年 12 月



(a) 25.8L/分/m　(b) 10.4L/分/m

図 4　熱移動の割合（両面水膜方式の場合）

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日本建築学会大会学術講演梗概集
（中国） 2008年 9 月

水膜を用いる防火設備の開発
その１ 水膜表面での対流熱流束・物質移動について

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火災安全性能 防火区画 水膜
数値解析 火災実験

１．はじめに

火災時に水を用いる防災システムは、水を使用した消火設備での安全性の歴史から様々な提案がなされている。防火区画の研究としては本研究グループが水膜を用いた防火設備の解析モデルを提案し、水膜と壁面及び火災側間での熱及び質量流束の簡易解析及び計算式を提案している[1]。（図１参照）

図１に示すように水膜表面では熱放射 Q_R と対流熱伝達 Q_C 及び蒸発熱による熱移動 Q_P 等があるが、本研究では水膜表面と火災ガス間での対流熱伝達 Q_C と蒸発 Q_P について検討した。まず、これらの性状を表す関係式を調査し、火災のような高温域で利用可能であるか、装置を製作して実験を行い計算結果と比較して評価した。さらに、水膜設備を用いた防火安全設計を行う時に必要となる一般的な火災時における熱伝達係数と物質移動係数の考え方について検討を行ったので報告する。

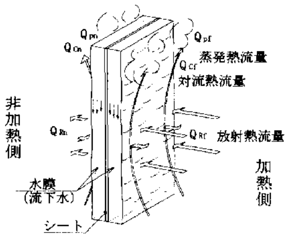

図１水膜防火設備の簡易解析モデル参考図

２．熱伝達係数・物質移動係数の算定法

流下水膜面とガス流間の気相物質移動係数 k に対しては Gilliland･Sherwood 式[2](1)式がある。液面とガス流間での物質移動係数及び拡散係数とガス側の Sc 数 Re 数等の関係式であり、ガス側の条件と拡散係数から、物質移動係数を求めることができる。一方、液体が水の場合には、物質移動係数 k と熱伝達係数 h の関係式として、ルイスの関係式[2](2)式があり、(1)式により物質移動係数(k)を求めれば(2)式から熱伝達係数(h)が得られる。((1)式の物質移動係数 k と(2)式 k^* は単位系が異なるので換算が必要)

$$\frac{kRT_f D}{D_G}\frac{(p-p_n)}{p}=0.023\left(\frac{\mu}{\rho_G D_G}\right)^{0.44}\left(\frac{DG}{\mu}\right)^{0.83} \quad (1)$$

$$\frac{h}{k^*}=C_H \quad (2)$$

３．確認実験
３．１ 実験装置及び実験方法の概要

水面に高温ガスが吹き付けられたときの表面での物質移動量（蒸発量）と熱移動量を測定するために、図２に示す実験装置を製作し、実験を行った。

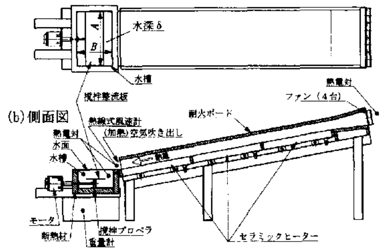

図２ 実験装置全体の概要

高温ガス流は、耐火ボードで構成し底面をセラミックヒータとした矩形断面の加熱ダクト内をファンで送気して発生させた。水槽の水面に対してダクト側の熱放射が極力入らないように吹き出し口は水面の側方に配置した。ＳＵＳ製の水槽は断熱材で覆い、水温を均一にするために樹脂製の電動撹拌プロペラを設けた。水の蒸発量は重量計で計測し、吹き出し口に熱線式風速計と熱電対、水槽内に熱電対、周囲雰囲気の湿度計と熱電対を設置した。

実験は、室温の水槽水表面に加熱空気を送風して開始し、250 分間の昇温の後にヒータの電源のみを切り、さらに 250 分間送風して冷却した。その間 10 秒ごとに各データを収集した。

３．２ 実験時の算定モデル

(1)、(2)式で得られる物質移動係数 k と熱伝達係数 h を用いた上記実験装置の熱量収支式及び質量収支式を、(3)式、(4)式に示す。

＜熱量収支式＞

$$(ABC_W\rho_W\delta|_{t+\Delta t}+m_SC_S)T_W|_{t+\Delta t}-(ABC_W\rho_W\delta|_t+m_SC_S)T_W|_t$$
$$=ABh(T_f-T_W)\Delta t-AB\varepsilon\sigma(T_W{}^4-T_n{}^4)\Delta t+P_K\Delta t$$
$$-\Delta h_{vap}ABk(p_T-p_n)M_W\Delta t-\{2(A+B)\delta+AB\}\frac{(T_W-T_n)}{(L_S/\lambda_S+1/h_H)}\Delta t \quad \cdots(3)$$

＜質量収支式＞

$$AB\rho_W\delta|_{t+\Delta t}-AB\rho_W\delta|_t=-ABk(p_T-p_n)M_W\Delta t \quad (4)$$

３．３ 実験結果と計算結果の比較

水温及び水槽内の水量の時間推移について、実験結果と前記算定法((1)～(4)式)の計算結果を図３に示す。水温は 40℃迄ではあったが計算による水温及び水質量の時間推移は温度上昇期ならびに冷却期ともに実験結果と概ね一致した。

Development of Fire Prevention Equipment with Water Film
Part1: Convection of Heat and Mass Flux on Water-Surface

TSUJI Toshihide, HAYASHI Tatsuya, KURIOKA Hitoshi, KUWANA Hideaki, TANOUE Toyoaki and YOKOI Naoki

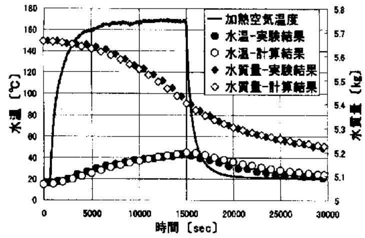

図3 水温･水質量の時間履歴

提案する算定法、つまり、高温ガス下の水膜面の対流熱伝達において物質移動係数は Gilliland･Sherwood 式により求め、熱伝達係数はさらにルイスの関係式により物質移動係数から求める方法で、実験結果と概ね一致する結果が得られたものと考えられる。

4．火災時の物質移動及び熱伝達係数

次に、防火設備の設計を行うために前記算定法を用いて一般的な火災時における熱伝達係数と物質移動係数の概算方法を検討した。

4．1 主な変動要因の検討

前記算定法において、物質移動係数・熱伝達係数に対して、ガス温度、ガス流速、ガスの絶対湿度、ガス粘度、ガス密度などの要因が影響を与える。これらの要因がその係数に及ぼす影響度合いを把握するために、要因ごとの影響を求めた。その一例としてガス流速とガス温度をパラメーターにした熱伝達係数を図4に示す。ガス温度が上昇すると、ガス質量速度が小さくなる等の理由により熱伝達係数は減少した。ガス流速が速くなると熱伝達係数は大きくなった。なお、ガス絶対湿度・粘度・密度の要因は影響が小さかった。

4．2 火災安全設計用の考え方

提案する算定法を用いて火災安全設計法の中で水膜設備を評価するために、一般的な火災における水膜面での物質移動および熱伝達係数の概算値を求めることにした。算定法の中で最も大きな影響要因であったガス流速とガス温度に対し、流下水に接する高温ガスの温度と流速の関係に、拡散火炎モデルの工学式[3]を導入して検討した。

水膜を用いた防火設備を区画として用いる場合の設備の最高高さを 8m 程度とし、中間位置である 4m 位置での火炎温度と流速の値を用いて、熱伝達係数及び物質移動係数の関係を算出した。結果を図5に示す。

火災場の水膜表面での熱伝達係数・物質移動係数は、300～800℃の温度範囲では、ほぼ一定値を示し、概ね下記の値を示した。

物質移動係数 k^*：1.5×10^{-2} 〔$kg\cdot m^{-2}\cdot s^{-1}\cdot \Delta Y^{-1}$〕
熱伝達係数 h：16〔$W\cdot m^{-2}\cdot K^{-1}$〕

5．結論

水膜面の高温ガス流による蒸発現象が伴う物質移動係数ならびに熱伝達係数については下記のことが判明した。
①熱伝達は、Gilliland･Sherwood 式を用いてその物質移動係数からルイスの関係式で求める方法により、実験結果を記述できる。
②物質移動係数及び熱伝達係数は、ガス流速及びガス温度の影響が支配的である。
③拡散火炎が水膜面に接炎する場合の物質移動係数と熱伝達係数は、300～800℃の温度範囲でほぼ一定値を示した。

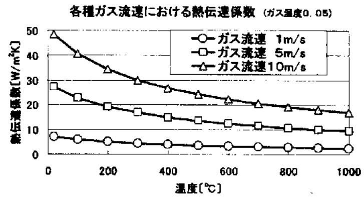

図4 ガス流速及びガス温度と熱伝達係数の関係

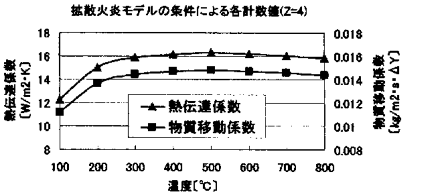

図5 拡散火炎モデル導入による各係数値

6．終わりに

本研究では、水膜を用いる設備における熱及び質量流束の解析において、対流熱伝達及び水の蒸発量の解析手法を提案し、さらに防火設備における概算に有用な目安としての水膜－火災ガス間の熱伝達係数と物質移動係数の概算を試みた。今後さらに実験等を行い、水膜を用いる設備における熱及び質量移動全体の簡易解析モデル式の検討を行いたい。

<記号>
Q：熱流量〔W〕
添字　R：放射、C：熱伝達、p：蒸発　f：加熱側　n：非加熱側
k：物質移動係数〔$mol\cdot m^{-2}\cdot s^{-1}\cdot Pa^{-1}$〕
k^*：物質移動係数〔$kg\cdot m^{-2}\cdot s^{-1}\cdot \Delta Y^{-1}$〕
R：気体定数〔$J\cdot mol^{-1}\cdot K^{-1}$〕 T_f：加熱側温度〔K〕
D：代表長さ〔m〕 D_G：ガス側拡散係数〔$m^{-2}\cdot s^{-1}$〕
p：大気圧〔Pa〕 p_n：ガスの水蒸気圧〔Pa〕
μ：ガス粘度〔Pa･s〕 ρ_G：ガス密度〔$kg\cdot m^{-3}$〕
G：ガス質量速度〔$kg\cdot m^{-2}\cdot s^{-1}$〕 h：熱伝達係数〔$W\cdot m^{-2}\cdot K^{-1}$〕
C_H：湿り比熱容量〔$kJ\cdot kg^{-1}\cdot K^{-1}$〕 C_w：水比熱〔$J\cdot kg^{-1}\cdot K^{-1}$〕
ρ_w：水密度〔$kg\cdot m^{-3}$〕 A：水槽の横幅〔m〕 B：水槽の縦幅〔m〕
δ：水深〔m〕 t：時間〔s〕 ms：SUS 総質量〔kg〕
Cs：SUS 比熱〔$J\cdot kg^{-1}\cdot K^{-1}$〕 T_W：水温〔K〕 ε：水の放射率〔-〕
σ：ステファン・ボルツマン定数〔$W\cdot m^{-2}\cdot K^{-4}$〕
P_k：攪拌動力〔W〕 Δh_{vap}：水蒸発潜熱〔$J\cdot kg^{-1}$〕
p_T：TK の飽和蒸気圧〔Pa〕 M_w：水モル質量〔$kg\cdot mol^{-1}$〕
λ_s：断熱材熱伝導率〔$W\cdot m^{-1}\cdot K^{-1}$〕 Ls：断熱材厚さ〔m〕
T_n：場内温度〔K〕 h_H：断熱材-空気熱伝達係数〔$W\cdot m^{-2}\cdot K^{-1}$〕

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日本建築学会大会学術講演梗概集
(中国) 2008年 9 月

水膜を用いる防火設備の開発
その2 防火・防煙区画形成の確認実験

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同 辻 利秀*2 同 林 龍也*2
同 栗岡 均*3 同 桑名 秀明*3

火災安全性能 防火区画 水膜
遮煙性 遮炎性 遮熱性

1. はじめに

火災時の建築空間の区画に求める機能としては法規に規定されている遮炎性、遮煙性以外に火災初期には避難や消防活動の観点より遮熱性や透視性などがある。火災時に木質系材料の表面に事前散水し延焼を防止する研究[1),2)]などで報告されているように、水を用いた防災システムでは遮熱効果が期待できる。今回模型実験にて水膜を用いる防火設備の遮煙性実験と遮炎・遮熱性実験を実施したので、結果を報告する。

2. 防火設備の概要

水膜を形成させるために、本実験では図1に示すようにメッシュ加工を施したクロス材に散水を行った。通気性材料に水膜で気密性をもたせることで、①散水ノズルの簡易化（片側給水で両面に水膜を形成させる)、②区画としての膜面の保全（機械排煙などで過大な差圧が発生した場合、水膜が破壊し、クロス材自体の破壊を防ぐ)、などの効果が期待できる。

3. 遮煙性実験

遮煙性を確認するために、気密チャンバー付き実験装置(幅：2.5m、高さ：3 m)を作成し、その一面にクロス材を取り付け、上部に設置した散水ノズルから散水しクロス材表面に水膜を形成させた。ファンからチャンバー内に送風もしくは排気し水膜の遮煙性実験を行った。

3. 1 散水設備

10cm ピッチでソリッドノズル, 50cm ピッチでフラットノズルを配した。ソリッドノズルからの水は装置上部に設置した樋に溜めクロス材に供給した。

3. 2 実験条件

散水量としては 12､16 および 20L/m/min の 3 条件とし、気密チャンバー内外圧力差を±9.8～49Pa 及び 49～147Pa の 2 シリーズで変化させ、ベンチュリー管内の風速、温度を測定し、漏気量を式(1)により求めた。

$$q=\frac{Q}{A}=\frac{V\cdot a\cdot 60}{A}\times\frac{P}{1013}\times\frac{273+20}{273+t} \qquad (1)$$

3. 3 実験結果

各散水量下での差圧と漏気量の関係を図2に示す。外気に対してチャンバー内が正圧の時は、どの散水量でも 19.6Pa で漏気量は 0.2 ㎥/㎡/min 以下で遮煙性の基準を満足している。この差圧下の漏気は主としてガイドレールからである。

散水量 12L/m/min では 19.6Pa で、16、20L/m/min では 29.4Pa で漏気量の増加傾向が大きくなるのは座板(クロス材の下端に取付けた部材)が床面から浮き、開口が生じるためである。実験を行った範囲では、散水量が多い方が厚い水膜が形成され、その結果、座板に掛かる力が大きくなり、座板の浮上りが小さくなると共に漏気量も少なくなるものと考えられる。

さらに高圧下での水膜の挙動を把握するため、座板を錘で押え、差圧 49～147Pa の間での漏気量を測定した。散水量を 20L/m/min とした結果を図3に示す。

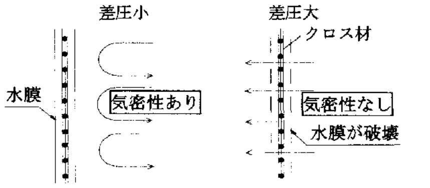


図1 防火設備の概念

49Pa における両シリーズの漏気量の差 0.45 ㎥/㎡/min は座板の浮きによる開口が原因である。

また、約 100Pa から漏気量の増え方が大きくなるのは水膜破壊(クロス材に水膜が形成されない現象)が原因である。

以上より水膜を用いた防火設備の漏気量は式(2)によって表わされる。 $L=L_1+L_2+L_3$ (2)

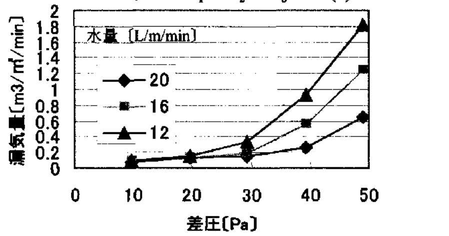


図2 散水量変更時の漏気量と差圧の関係

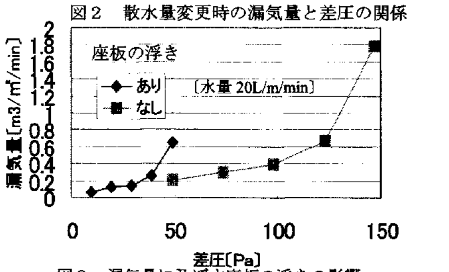


図3 漏気量に及ぼす座板の浮きの影響

Development of Fire Prevention System with Water Film
Part 2 Experiments on Formation of Fire Compartment

TANOUE Toyoaki, YOKOI Naoki, TSUJI Toshihide, HAYASHI Tatsuya, KURIOKA Hitoshi, and KUWANA Hideaki

4．遮炎・遮熱性実験

表 1 に示す仕様の加熱炉にて、標準加熱曲線に準拠した加熱（1 時間で 945℃）を行った。加熱炉開口部に表 2 に示す加熱用模型を設置した。

表1　加熱炉の主な仕様

項　目	摘　要
開口寸法	幅 1900mm×高さ 900mm
加熱炉奥行	1200mm
加熱方式	ガスバーナー9 機
排気方式	炉上部からの自然排気

表2　加熱用模型の主な仕様

項　目	摘　要
被加熱面寸法	幅 1900mm×高さ 900mm
クロス材構造	水平方向畝のメッシュ構造
散水方向	クロス材表面へ鉛直下向き
散水ノズル	41 個を列状配置(間隔 50mm)

4．1　実験条件及び実験ケース

散水量は開口幅方向単位長さ当たりの換算値で定流量弁を用いて 10、15、20、25 [L/m/min]とした。散水ノズルとクロス材は一定角度で接触させて、散水がクロス材表面に有効に広がるようにした。実験ケースはクロス材２種類(粗目と細目)と散水量４種類を組み合わせた。

4．2　測定項目

炉内温度、試験体非加熱面温度、非加熱側雰囲気温度を、図 4 の位置にシース熱電対(K 型：シース径 1.6mm)を取り付け測定した。また、熱画像カメラで非加熱面の温度分布を測定した。

4．3　実験手順

実験は次の手順で行われた。

①クロス材に対して散水を開始した後加熱炉を運転。
②加熱温度の変化が緩やかになった事を炉内温度測定値にて確認し、試験体への加熱は継続しながら５分毎に散水量を減らす。
③散水量を減らしていく過程で試験体に大きな穴が生じた場合は試験を中断した。

4．4　実験結果

図５(a)に示すように、炉内温度は 945℃を目指したが、水膜が形成されている間は水膜から炉内側への再放射が少なく、最高到達温度は約 850℃だった。

炉内温度が高温にかかわらず、図５(b)に示すように、非加熱面温度は 100℃以下であった。

加熱炉を用いた実験を行い、以下の知見を得た。

・散水量が少ないと試験体表面の水膜形成に不均一が発生した。その後ｼｰﾄの散水量が少ない部分に焼損が発生して垂直方向へ徐々に拡大した。焼損発生後に加熱炉内の温度は再上昇した。
・散水量 15～10L/m/min の時に焼損が発生していた。焼損発生前の非加熱面温度は 100℃以下であり、焼損発生後には該当部分への水膜形成はなかった。
・試験体開口部近傍の雰囲気温度は 50℃以下に留まった。水膜状態に不均一を生じている間も温度は維持された。

5．まとめ

・正圧下では差圧 19.6Pa で漏気量 0.2 ㎥/㎡/min 以下で遮煙性を満たしていた。
・水膜を用いた装置の漏気量は、(2)式のように水膜形成以外の設備全体を考慮する必要がある。
・水膜を用いた装置へ加熱をした場合、水膜が形成されている間、非加熱面温度は 100℃以下であった。また、開口部近傍の雰囲気温度は 50℃以下であった。

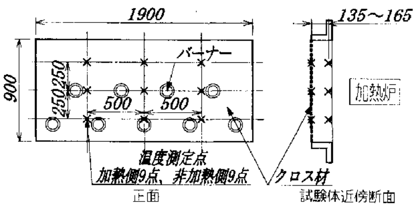
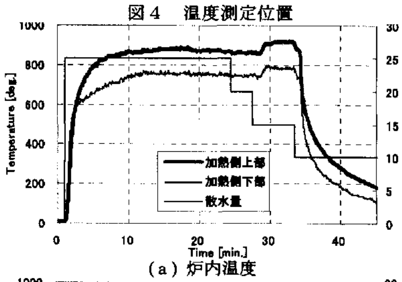
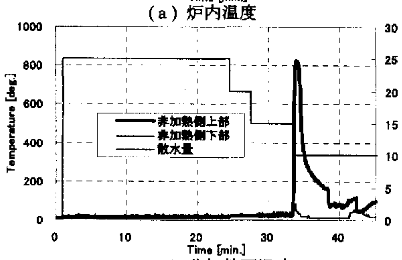


図４　温度測定位置



(a) 炉内温度



(b) 非加熱面温度

図５　各部温度の変化

記号

q：通気量(m^3/m^2/min)	t：測定空気温度(℃)
Q：総通気量(m^3/min)	L:総漏気量
V：ベンチュリー管内風速(m/sec)	L_1:ｶﾞｲﾄﾞﾚｰﾙなどからの漏気量
a：ベンチュリー管断面積(m^2)	L_2:座板浮きによる漏気量
A：内法面積[開口面積](m^2)	L_3:水膜破壊による漏気量
P：試験室の気圧(hPa)	

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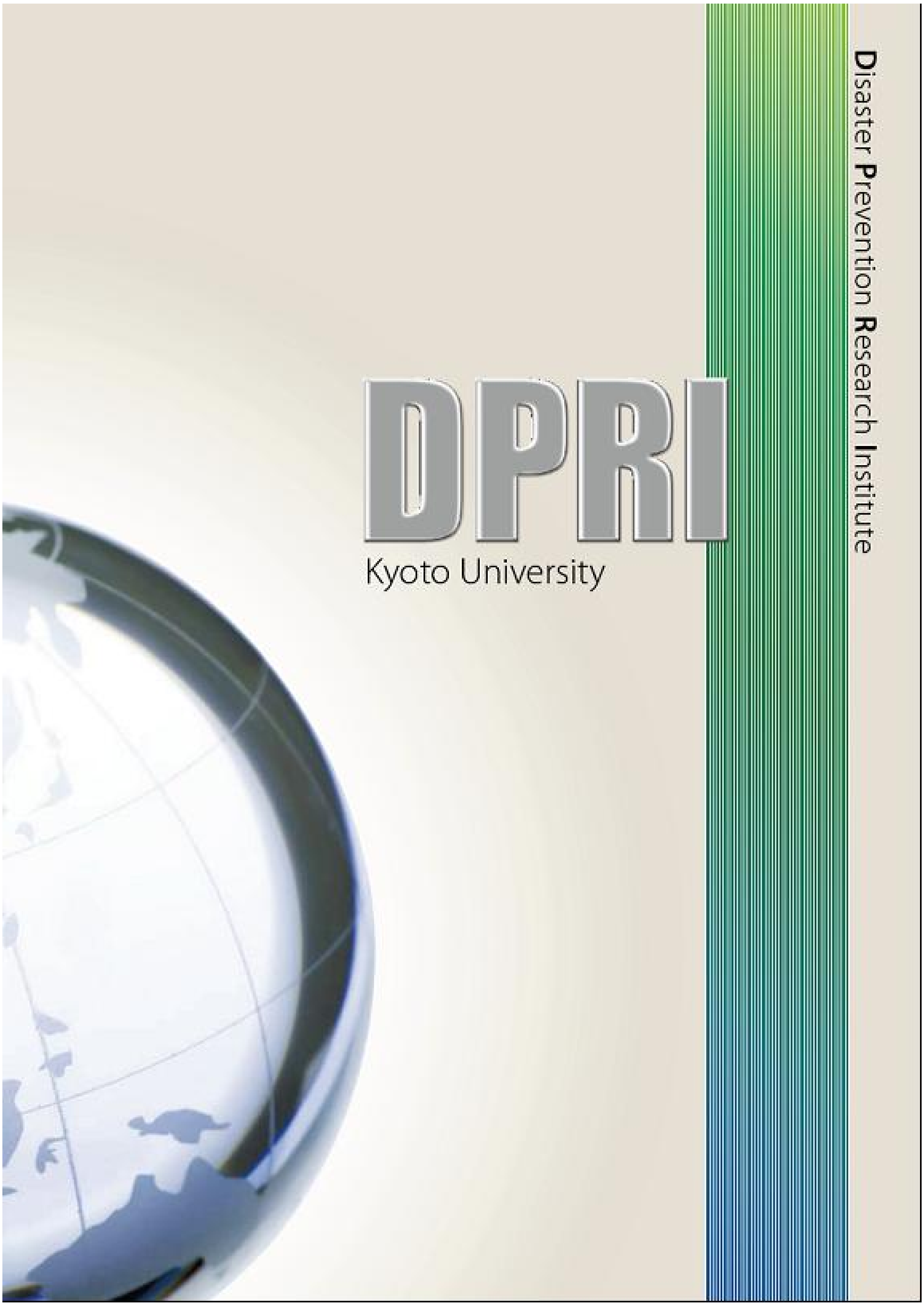
2) 栗岡均、桑名秀明、田上豊明、鈴木信、辻利秀、林龍也；「水膜を用いた防火設備の可能性」, 日本建築学会学術講演梗概集, pp.31-32, (2007)

*1 三和シヤッター工業株式会社　*2 ホーチキ株式会社
*3 鹿島技術研究所
*1 Sanwa Shutter Corporation　*2 Hochiki Corporation
*3 Kajima Technical Research Institute

四、京都大學防災研究所 DPRI－最新研究主題



Mission Statement

The mission of the Disaster Prevention Research Institute (DPRI) is to pursue the principles of natural hazard reduction, establish integrated methodologies for disaster loss reduction on the basis of natural and social sciences, and educate students in related fields. DPRI has been performing basic research on various disaster-related themes at local to global scales from the viewpoints of natural science, engineering, and human and social sciences, as well as conducting practical projects that meet the needs of society by organizing interdisciplinary groups. The scope of research, education, and social contributions of DPRI are as follows:

Research: DPRI will conduct comprehensive and practical researches on hazard prevention, as well as investigate mechanisms of natural hazards under the themes on disaster reduction in both local and global scales.

Education: DPRI will bring up students as future leaders, who have the ability to harmonize with global society holding well educated background and high human qualities, as part of undergraduate and graduate schools of Kyoto University utilizing accumulated results of hazard prevention researches.

Social contributions: DPRI will provide the public with scientific results and knowledge on natural hazards and advise national and local governments on hazard reduction strategies.

Administration: DPRI will run the institute as a Center of Excellence in the world as well as in Japan, taking in respect of human rights and environment and trying to establish balance with the sustainable society.

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Publications

Publications of DPRI are available on the website below:
http://www.dpri.kyoto-u.ac.jp/web_e/index_topics.html

Disaster Prevention Research

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Disaster Prevention Research

Contents

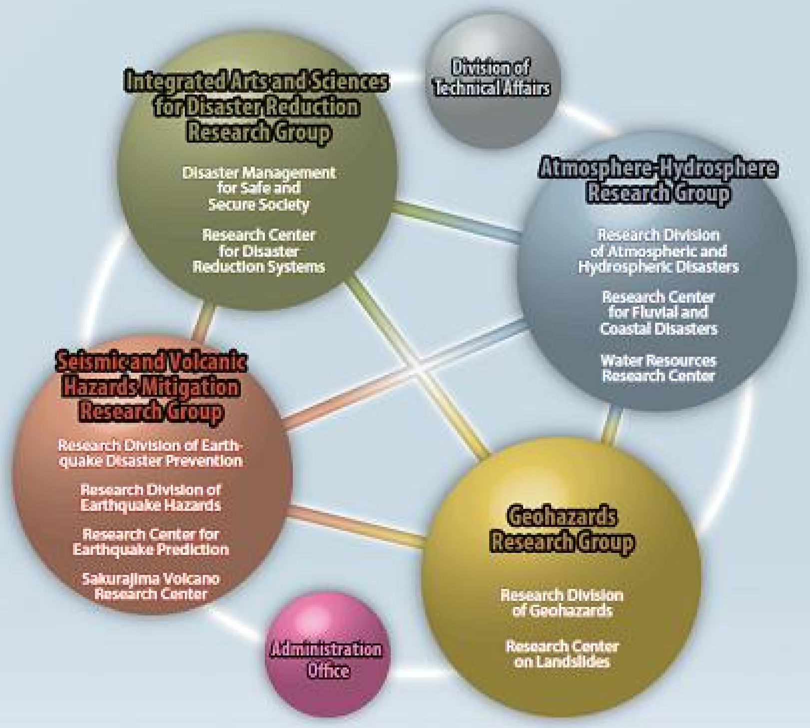
Preface

Japan is threatened every year by various types of serious natural hazards, including earthquakes, volcanic eruptions, typhoons, floods, landslides, tsunami, and coastal erosion. In particular, large earthquakes and typhoons have struck Japan in the late 1940s. In 1951, the Disaster Prevention Research Institute (DPRI) of Kyoto University was established for research on mechanisms of natural hazards and mitigation of disasters. Since then, DPRI has acted as a leader of natural disaster science, promoting interdisciplinary studies in collaboration with other universities and institutions in Japan. The mission of DPRI is to study the principles of natural hazards, establish integrated methodologies for disaster reduction based on natural and social sciences, and educate graduate students in science, engineering, and informatics. DPRI has five research divisions, six research centers, and a division of technical affairs. In addition, 15 laboratories and observatories located in western Japan conduct experimental studies and field observations on natural hazards. To promote integrated research projects, each Division and Center belongs to one of four research groups: Integrated Arts and Sciences for Disaster Reduction, Seismic and Volcanic Hazards Mitigation, Geohazards, and Atmosphere-Hydrosphere Research. DPRI provides the public with scientific results and knowledge on natural hazards and advises national and local governments on disaster prevention strategies.

DPRI has constantly been promoting international research and exchange programs with other leading universities and agencies around the world. As of June 2010 there are 29 Memoranda of Understanding with other institutes in 16 countries. In 2009, DPRI was designated by MEXT (Japanese Government) as a Joint Usage / Research Center. In this role, DPRI leads collaborative research with other academic and government institutes at home and abroad, in the fields of natural hazards and disaster management. Also, in cooperation with other institutes and graduate schools of Kyoto University, DPRI was selected in 2009 as the core institution of the Global Center of Excellence: Adaptation and Resilience in Sustainable/Survivable Society to extreme weather and water conditions (GCOE-ARS). The research staff is engaged in many other current scientific activities, thus DPRI is constantly renewing its specialized focus and staying on the cutting edge of research.

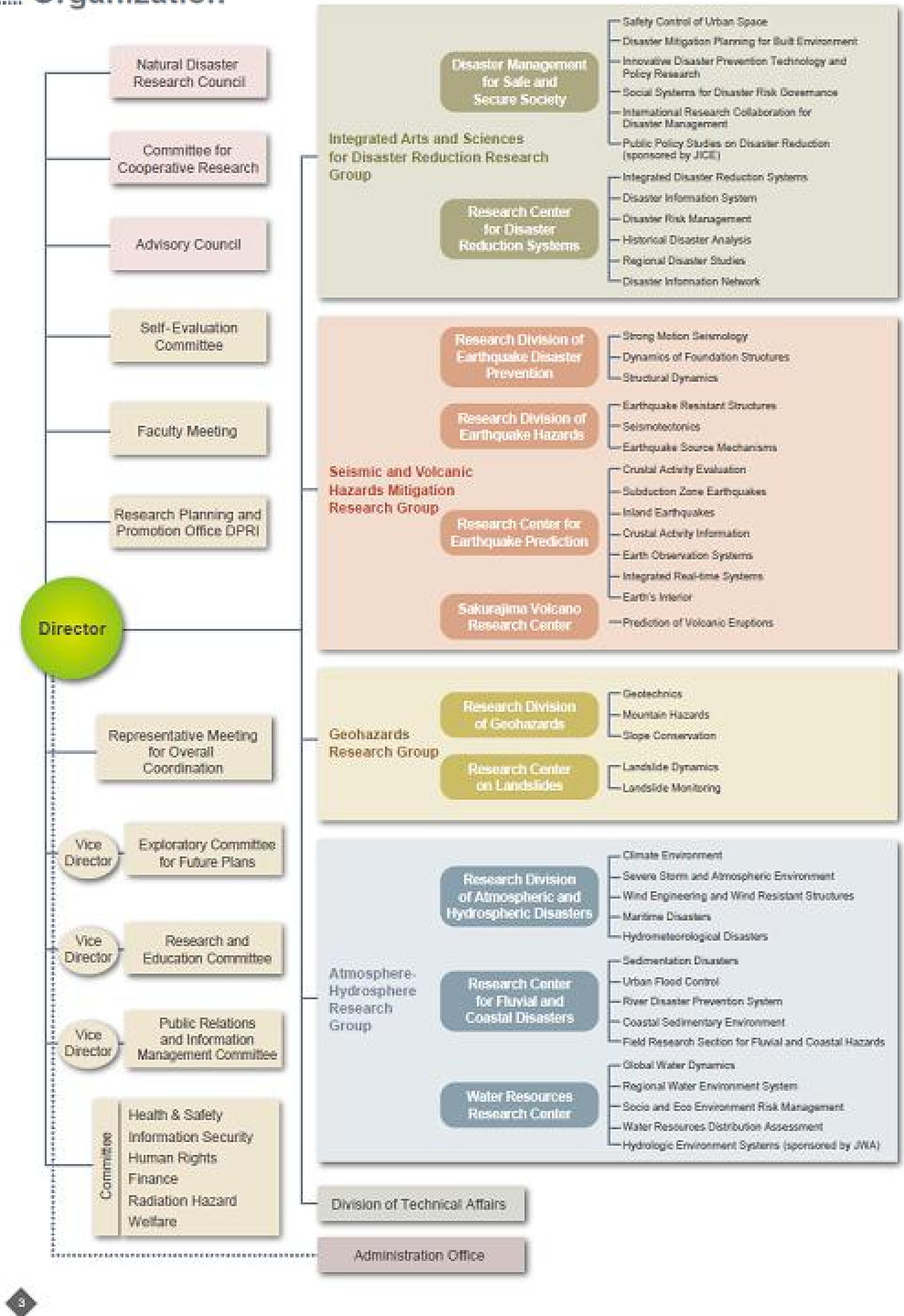
DPRI reorganized the existing five research divisions and six research centers and organized four groups of Integrated Arts and Sciences for Disaster Reduction Research Group, Seismic and Volcanic Hazards Mitigation Research Group, Geohazards Research Group and Atmosphere-Hydrosphere Research Group in 2005.

Organization of DPRI



The Overview of Uji Campus

Organization



Research Groups

Integrated Arts and Sciences for Disaster Reduction Research Group

Integrated Science and Technology which Contribute to the Realization of a Disaster Resistant and Resilient Society

This research group takes holistic approaches for effective use of the state-of-the-art science and technology for disaster reduction, considering the significance of human activities during hazardous events and impacts on socio-economic environment. Major themes include societal vulnerability being degraded against hazards, preventive measures for improvement of societal robustness and policies of recovery after disasters. This group focuses on long-term scientific perspectives about characteristics of multiple disasters due to social development and complexity, comprehensive diagnosis on vulnerability of the modern society against hazards, and development of technologies and methodologies of planning and management for disaster reduction.

Seismic and Volcanic Hazards Mitigation Research Group

Studies of Damaging Earthquakes and Volcanic Eruptions with Improvements of Related Technologies for Disaster Mitigation

Large earthquakes and eruptions of volcanoes in Japan bring more severe damage to society than other natural hazards. Accurate predictions of earthquakes and eruptions of volcanoes is very difficult, since they often have long and irregular intervals. However, when these events occur they can cause huge amounts of damage. Also the events cause fear and alarm among the population, die to as long durations of aftershock sequences or successive volcanic eruptions. The studies of this group are aimed at clarifying the physical processes of earthquakes and volcanic eruptions and extending the technical knowledge into applications that can reduce the effects of the natural disasters on society. With the cooperation of science and engineering researchers, the group pursues basic investigations along with seeking applied technologies for the built environment that protect human lives and property.

Geohazards Research Group

Prediction and Mitigation of Geotechnical, Hydrogeomorphic,and Geological Hazards

Soil liquefaction, ground settlements, landslides, erosion, and related phenomena are studied to identify the distribution, processes, mechanisms, and historical, anthropogenic conditions contributing to hazards, for establishing the hazard assessment and mitigation methodologies. These investigations incorporate combined process-based and modeling approaches to hillside and lowland hazards in both urban and mountainous regions. Integrated studies on landslides are performed with respect to the mechanism of initiation and motion, risk evaluation and disaster reduction, and developments of regional and global monitoring systems. Physical modeling with the geotechnical centrifuge and numerical modeling are intensively employed to study risk mitigation measures and performance of geotechnical structures.

Atmosphere- Hydrosphere Research Group

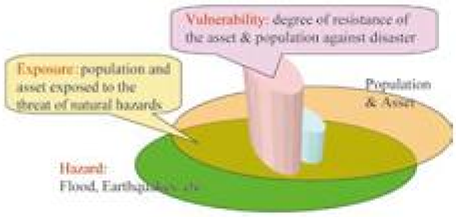
Mitigation of Atmospheric and Hydrospheric Disasters and the Conservation of the Aquatic Environment under Changing Global Environment Conditions

Impact assessment of global environmental change on general circulation and water circulation; development of innovative methodologies for water resources management and water environment conservation in harmony with water utilization and social activities; studies of atmospheric environments causing disasters, elucidation of hazardous climate, quantitative prediction of disastrous meteorological phenomena and prevention of wind damage; proposal of countermeasures for abnormal phenomena such as floods, storms, tidal waves and tsunamis; and planning of river basin environment management strategies considering sediment transportation processes ranging from soil erosion to estuary deposition.

Integrated Arts and Sciences for Disaster Reduction Research Group

Disaster Management for Safe and Secure Society

We aim to establish long-term research methodologies for comprehensive disaster management addressing to disaster resilient living spaces, cities, regions and the global society with due consideration of the lessons from past disasters and the evolution of human society. Using technologies and methodologies for disaster mitigation design and planning, we conduct scientific analyses and predictions of multiple processes of disaster, along with comprehensive diagnoses of the vulnerability and risk inherent in modern societies, which are rapidly changing and increasing sophistication. We aim to develop disaster management methods to construct desirable societies considering cultural aspects, sustainable development, safety, and comfort. We perform studies to elucidate human psychological and behavioral response to disaster risk as a function of human life and the natural and societal environments. Based on the understanding of the correlation between disaster processes and the socioeconomic environments, we establish theories of disaster mitigation policy that accommodate land development in harmony with safety and preservation of environment.



Three principal factors of a "disaster":
A natural phenomenon is not a "disaster" unless it causes any loss to human society. Hazard is an environment caused by a natural phenomenon, e.g., earthquake and flood. Exposure is the part of the population/assets threaten by a hazard. Vulnerability is the degree of resistance of the population/assets against the hazards. Exposure and vulnerability are dependent on activities in human society. Hence, human and social dimensions are important in disaster studies.

Safety Control of Urban Space

To develop a methodology for safety control of urban space and to materialize advanced living space with safety and comfort, we study risk evaluation methods of urban spaces subjected to strong ground motions and reliable design methods of urban space and built environments. We focus our research activities on the improvement of seismic performance of residential buildings and wooden houses that have close connections with the safety of residents. The main research topics are as follows:

1) Evaluation of seismic input to structures and urban facilities based on the regional characteristics of source, path, and sites and quantification of seismic risk for living space in relation to the seismic design policies.
2) Establishment of methods for the seismic reliability analysis and reliability-based design of buildings by considering uncertainty in structural parameters and seismic input motions.
3) Development of structural health monitoring and control systems including the damage evaluation of structures.
4) Development and promotion of new seismic designs and reinforcement methods for buildings, especially traditional wooden houses.
5) Development of technologies for reinforcement and restoration of historical and cultural buildings.

Shaking table test of a newly proposed column-wall

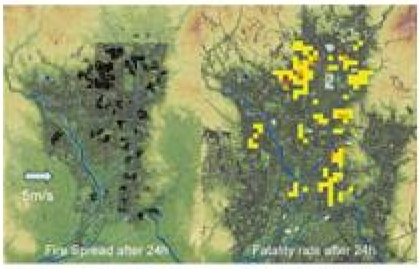
5

Disaster Mitigation Planning for Built Environment

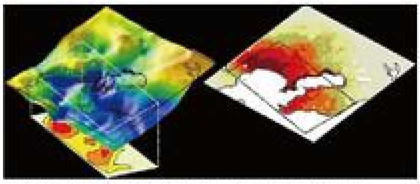
1. Assessments of Risks and Mitigation Measures of Potential Disasters in Built Environment
   1) We develop a model for predicting the behavior of post-earthquake fires, in the event an urban area is hit by a severe earthquake, assessment methods of the fire loss risk and urban planning methodologies for mitigating the risk.
   2) We develop methodologies for predicting the behavior and analyzing the hazards and risks of the evacuation of urban residents in post-earthquake fire.
   3) We explore methodologies for disaster mitigation urban planning in harmony with preservation and creation of desirable environment and cityscapes.
   4) We conduct studies for preserving cultural heritage buildings and city areas from post-earthquake fire.

2. Studies on seismic risk assessment in urban area:

   Methodologies of ground motion prediction for future earthquakes are developed integrating latest knowledge from geophysics, geology and earthquake engineering. Basic studies on earthquake source process, crustal structures and seismic wave propagation as well as applications are carried out.



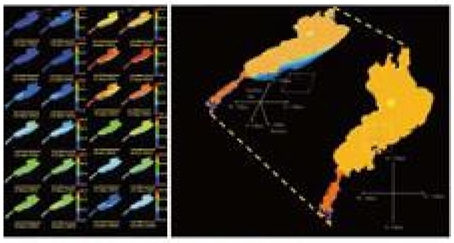
Post-earthquake fire spread and residents' evacuation


Source, crust structure and simulated ground motion

Innovative Disaster Prevention Technology and Policy Research

Throughout development of innovative technologies such as advanced spatiotemporal modeling for predicting floods and sediment disasters, computer intensive simulation analysis for global environmental changes, and remote sensing, we aim at applying them to leading-edge monitoring and prediction of natural and/or human-induced disasters, as well as risk and emergency management. The analyses of interactions between social changes and hydrological cycle/water-related disasters, policy development for secure and sustainable social systems, and international disaster mitigation strategy are also research themes. The research topics include:

1) Spatiotemporal modeling of disasters for advanced prediction systems.
2) Interaction process analyses between social change and hydrological cycle/water-related disasters and policy development for secure societies.
3) Computer intensive statistics and simulation analysis of extreme events for disaster mitigation planning.
4) Remote sensing technologies targeting disaster monitoring and management.
5) Integrated numerical modeling for lakes and surrounding catchments.

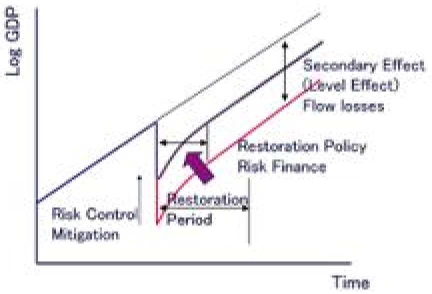

Application of Biwa-3D to lake hydrodynamics


Laboratory experiment for sediment disaster - debris flow

Social Systems for Disaster Risk Governance

To realize safe and secure society, integrated disaster risk governance is a key infrastructure which supports designing and implementing integrated disaster risk management policies which consist of risk control and financing. We investigate an ideal figure of disaster management system through informational, organizational and economic approach. Considering disaster risk governance and/or management, public involvement and participatory approach to planning are also essential frameworks. Our research section focuses human behaviors before/during/after disaster and aims at constructing original methodology for efficient integrated management of disaster risk. From this perspective the current research topics are as follows:

1) Integrated Management for Infrastructure and Logistics.
2) Policy Analysis of Disaster Mitigation.
3) Economics Analysis of Disaster Risk.
4) Disaster Risk Communication.
5) Spatial Temporal GIS for Disaster Management.



How risk control and risk finance reduces economic losses? :
Red line and blue line in the figure corresponds to the economic growth paths without/with these countermeasures. Risk control countermeasures contribute for reduction of the depth of downward jump. Risk financing countermeasures induce quick recovery of the economy. Hence, both countermeasures can reduce economic losses in the society.

International Research Collaboration for Disaster Management
(International Visiting Professors)

International collaboration for exploring integrated disaster risk management involves cooperating with innovative researchers working in the field of disaster science at leading institutions around the world in order to elucidate disaster mechanisms for various socio-cultural contexts; to utilize the information technology in disaster mitigation; and to carry out joint research with young scholars from high-risk countries. This function is served by inviting talented researchers and technicians from various countries to our institute. This research section promotes:

1) Collaboration research on state-of-the-art disaster science and disaster prevention methods.
2) Collaboration research on disaster counter-measures, focusing on practical approaches for a variety of socio-cultural environments.
3) Collaboration research on social implementation of disaster management methods in disaster-prone countries.
4) Collaboration research on development of original knowledge and methods toward common issues of disaster among Japan and foreign countries.

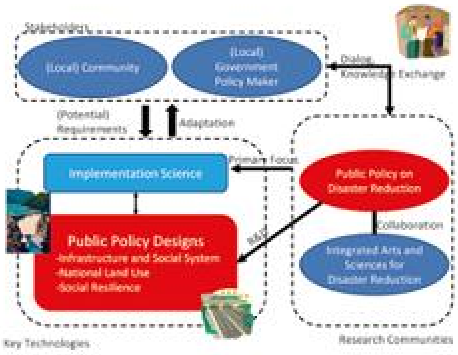
Special lecture by guest professors

Public Policy Studies on Disaster Reduction (sponsored by JICE)

The research sector of 'Public Policy Studies on Disaster Reduction' aims at assessing effects of existing public policies and providing more effective and efficient alternative damage reduction policies before and after the disasters. Collaborating with other research groups of 'Integrated Arts and Sciences for Disaster Reduction', heuristic and interdisciplinary basic/applied researches are oriented considering the latest requirements on public policies of land use.

'Implementation Science' is a key concept to put developed policy designs to practical use. For this purpose, most of the research developments are attempted through the practical dialogs and knowledge exchanges with stakeholders such as local community, firms and policy makers. In specialty, the following research themes are our main targets of research developments:

1) Disaster risk assessment reflecting vulnerabilities of national infrastructures and social systems.
2) National land use policies for integrated disaster prevention/mitigation.
3) Public polices for enhancing social resiliencies to unscheduled events.



Framework of public policy research on disaster reduction

This research sector is placed by the donation of Japan International Cooperation Center (JICE) and all the research outcomes are accessible to public.

Column Uji Campus and Surroundings

8

Research Center for Disaster Reduction Systems (DRS)

Developed countries like Japan are subjected to the progression of disaster vulnerability as the urban social structures develop to a great extent. Developing countries also face the progression of vulnerability caused by population increase, economic development and environmental problems. It is a grave concern that increased world vulnerability could increase the risk of catastrophic disasters. A catastrophic disaster strikes and spreads not only by abnormal natural forces but also by human factors. Thus, an integrated disaster reduction system, both prevention, prepared ness and resilience, must be promoted by establishing "Science of Implementation" as a new study area, and by conducting a series of domestic and international collaborative researches by a multi-disciplinary research team consisted of natural scientists, engineers, and social scientists.

DRS research network is formed by seven full-time professors, five domestic and international visiting professors, in addition seven scholars serving as researchers as well as lecturers to promote global disaster researches, as indicated in integrated study of entire processes of the 1995 Kobe earthquake and its recovery.

The center carries on the task of collecting and archiving documentary records from the reconnaissance surveys of major disasters in and out of Japan carried out since the establishment of Disaster Information Center.

DRS Research Scope

Integrated Disaster Reduction Systems

The research field promotes research and practice to build a safe society by reducing disaster damage, particularly from social scientific point of view. A special attention is focused on creating an integrated risk management system in which we emphasize practical action research and implementation science.

The followings are six major research targets:

1) Promoting citizens' participatory disaster management system in a local community.
2) Developing disaster education tools and methods to be used at a school and in a local community.
3) Developing countermeasures to reduce damages caused by big and complicated disasters like the Tokai, To-Nankai, and Nankai earthquake, and the earthquake in Tokyo Metropolitan Area.
4) Building a crisis management system for catastrophic natural and man-made disasters.
5) Analyzing disaster information from the viewpoint of social sciences such as mass media studies, risk communication studies, and narrative theory.
6) Creating theoretical foundation of implementation science in disaster reduction studies.

Disaster education at a kindergarten in Indonesia

Disaster education tools developed in the lab

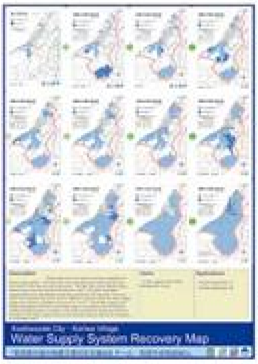
9

Disaster Information System

Natural disasters are social events as much as natural events. It is indispensable to establish a science and technology for studying social aspects of natural disasters. A goal of this research field is to carry out studies that enable effective emergency management after disasters based on the concept that emergency management is an information processing process. Studies in this section would be categorized into three topics such as 1) understanding of human behavior and psychological process before, during, and after disasters; 2) effective crisis management for emergency management organizations; 3) long-term recovery processes. The section promotes empirical studies based on various research methods such as ethnographic research and interviews, archival research, social survey with multivariate statistical analysis, numerical simulations and GIS technology.

Followings are research topics in this section:

1) Multi-hazard Risk Assessment.
2) Hazard Mapping.
3) Participatory Strategic Planning.
4) Emergency Planning.
5) Disaster Information System.
6) Incident Management System.
7) Standardization of Emergency Operations.
8) Human Resource Development System.
9) Risk Communication & Education.
10) Cross media database for disaster reduction.



Emergency Mapping Project For 2007 Niigata-ken Chuetsu-oki earthquake

Disaster Risk Management

Under this globalizing society disaster issues are becoming more and more interrelated with environmental problems and social conflicts. Thus sustainable development and citizen participation tend to come under the extending scope of integrated disaster risk management. DRM takes challenges for this interdisciplinary science which requires for an appropriate combination of various approaches such as systems engineering, micro economics, sociology and behavioral science, as well as developing conceptual models.

DRM gives greater importance to the development of methodologies for the analysis and assessment of proactive countermeasures such as mitigation policies, disaster insurance or fund, risk communication and social preparedness.

Current research focuses are as follows:

1) Participatory disaster risk management at community and regional levels. See an example of the Yonmenkaigi System Workshop Method (YSM) as illustrated below.
2) Performance evaluation of infrastructures under disaster risks.
3) Economic evaluation of disaster risks.
4) Disaster risk communication: methods and practices.
5) Mitigation policy analysis.
6) Reactive strategies of disasters.
7) Disaster risk governance.
8) Theories of international disaster risk management.
9) Sustainable community management under disaster and social risks.

Implementation of YSM in Japan

Historical Disaster Analysis (Visiting Professors)

This research section continues to study the historical changes of characteristics of catastrophic disasters, countermeasures and societal responses including law, construction standard and information systems based on documents, data and literatures. As the contribution to establishment of the resilient societies, which can overcome mega-city, wide-area, compound or long-term disasters, following two subjects are essential theme of this research section:

1) The damage processes of the disaster in megacities or in superwide area and change of them in the future.

2) Impacts on societies due to catastrophic disasters and damage reduction through self and community empowerment.

For the promotion of disaster research, five regional disaster science information centers of Japan and this center as the leader have been collecting and analyzing disaster related documents and data since 1982. The amount of collected resources has reached 106,000 documents in March 2010. The bibliographical information of these documents and data are registered to the database "SAIGAI" and searchable at http://maple.dpri.kyoto-u.ac.jp/saigai/.

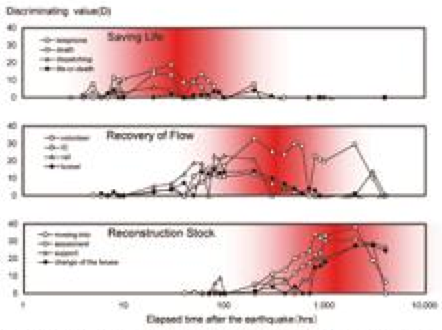
DRS is also extracting and collecting disaster related records from Japanese vast archives such as "Chronicles of Japan" or "Sequel of Chronicles of Japan". At March 2010, 13,000 descriptions has been extracted and 28,000 descriptions has been deciphered and translated in to modern Japanese. These historical disaster records are organized by era, region and type of disaster and available at http://maple.dpri.kyoto-u.ac.jp/saigaishiryo/.

Database "SAIGAI" and Historical Disaster Database

Regional Disaster Studies (Visiting Professors)

This special research section (mainly engaged by visiting researchers) provides research assistance to a nation-wide network community of researchers and experts in disaster reduction called "the Japan Council of Natural Disaster Sciences" (or "Nihon Saigai Kyougikai"). The section primarily deals with the following: 1) Development of the network of researchers engaged in natural disaster science in Japan. 2) Planning and coordination of post-disaster urgent investigation and 3) Promotion of regional disaster reduction information network projects.

As an example, we have developed a text mining system: TRENDREADER™(TR) that supports reading and understanding text data such as interview, open-ended answer of questionnaire survey, news report, and incident response log, with which we can develop and test theories on human behavior and social response in the disaster recovery. This system automatically extracts and visualizes keyword sets from a huge digital text corpus using natural language process technologies and statistics analysis methods. What we have achieved by applying the TR system are the following three things: validation of a theoretical model on disaster chronological process, supporting information gathering for domestic researchers and practitioners by sending e-mail letters to let them know our analytical results, and comparison between the case of the 2004 Niigata-ken Chuetsu earthquake and the case of 2007 Niigata-ken Chuetsu-oki earthquake.



TR analysis of Yahoo! news on the 2004 Niigata-ken Chuetsu earthquake

Disaster Information Network (International Visiting Professors)

Global networking of the people who are interested in holistic disaster reduction is a prime importance for DRS. In order to promote the international network of those people; it is available at DRS one visiting professorship specially reserved for those scholars and experts with foreign nationals.

He/she will be hired by Kyoto University as a visiting research scholar and appointed as a "visiting professor of Disaster Prevention Research Institute. During his/her stay at DRS, it is his/her main mission to promote the collaborative research with DRS staff and students in the area of his/her research interest. Even though we appreciate your lectures of your expertise and interest, no teaching obligation will be imposed. The appointment will be on one year basis (even though it is renewable), with a minimum stay of three months.

If you are interested in this position, please contact E-mail: hayashi@drs.dpri.kyoto-u.ac.jp

In close relationship to the activities in this research field, the center has organized an annual international symposium, "Comparative Study on Urban Earthquake Disaster Management," since 2001. The symposium contributes much to promote comparative and interdisciplinary studies on disaster risk management in the world. In addition, DRS hosts following workshops; Disaster Reduction Seminar for disaster managers (annually) which share research output of DRS, and experiences of disaster response among practitioners, Disaster Visualization Workshop (bi-annually).

Long term recovery process from the 2005 Hurricane Katrina was discussed in the symposium

Column Natural Disaster Research Council

Natural Disaster Research Council (NDRC) was established at the Disaster Prevention Research Institute (DPRI) in 2001 to manage the followings:

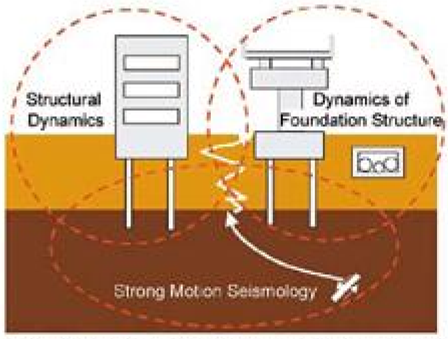
1) Planning and investigation of natural disaster research.
   The council aims to play a key role in the natural hazard research community by planning, research and development, promotion and liaison and coordination. DPRI serves as a core organization of natural disaster research community.
2) Organizing reconnaissance teams for natural disaster events.
   The council collects information of natural hazards occurred in foreign countries as well as in Japan and organizes and dispatches reconnaissance teams after events which have large impacts on society and research community.
3) System and budget for natural disaster research.
   The council is operated by the administrative budget of the DPRI, Kyoto University.
4) Establishing a natural disaster research network
   The council establishes a database of researchers who study natural hazards. Regional committee offices collect related information, and promote and coordinate natural hazard research projects.

Research Flow of Project and Operation for Outbreak of Disaster

Seismic and Volcanic Hazards Mitigation Research Group

Research Division of Earthquake Disaster Prevention

Theoretical and experimental studies are conducted with the aim of preventing and mitigating earthquake-induced disasters. The Strong Motion Seismology Laboratory studies earthquake source, propagation path, and site effects for strong motion prediction. The Dynamics of Foundation Structures Laboratory conducts research spanning the range from fault rupture processes to design and maintenance for civil engineering structures. The structural Dynamics Laboratory studies the dynamic characteristics of building structures to improve seismic designs of buildings, including foundations. This division consists of researchers in geophysics (Strong Motion Seismology Laboratory), civil engineering (Dynamics of Foundation Structures Laboratory), and architectural engineering (Structural Dynamics Laboratory) who cooperatively investigate broad research areas from strong motion generation to life-threatening earthquake disasters. Comprehensive research on earthquake disaster mitigation is also conducted with members in the Division of Earthquake Hazards and related fields.

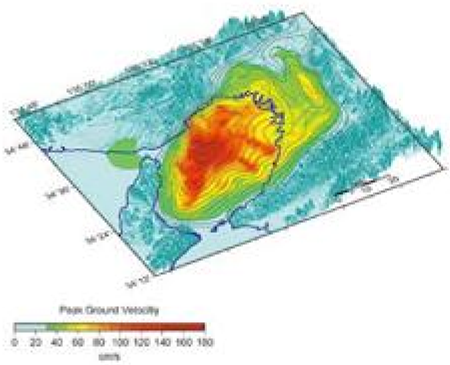


Schematic relation chart of the Division of Earthquake Disaster Prevention

Strong Motion Seismology

Both observational and theoretical researches on earthquake source, seismic wave propagation, and site effects are carried out to study strong motion characteristics and to develop advanced methodology for strong ground motion prediction to evaluate the seismic hazard for destructive earthquakes. Research topics in this section are as follows:

1) Seismic wave generation in earthquake source: Source inversion using strong motion data, Characterization of heterogeneous fault rupture for inland crustal, subduction, and intraslab earthquakes, Dynamic source modeling, and Near-source and extreme ground motions controlled by source process.
2) Seismic wave propagation: Long-period ground motion in crust and basin structure, Long-period ground motion simulation, Effects of surface geology on seismic ground motion, Non-linear site response, Sub-surface structure exploration using seismological techniques, and Seismic array observation.
3) Strong motion prediction for scenario earthquakes: Development of theoretical and semi-empirical broadband strong motion simulation methods, and Construction and validation of recipes to predict strong ground motions for scenario earthquake.


Prediction of peak ground velocity distribution in Osaka basin area for the hypothetical Nankai earthquake. The contours show bedrock depth of the three-dimensional basin structure model used in the long-period ground motion simulation.

13

Dynamics of Foundation Structures

Researches in Dynamics of Foundation structure laboratory aim (1) Integrate theories and methodologies related to the earthquake disaster mechanism: seismic source characteristics, nonlinear soil structure response, nonlinear dynamic response of structure systems, underground structures, and other civil engineering structures. (2) Develop rational seismic design methods for those structures.

1) Engineering Seismology: Investigation of seismic source mechanisms considering the rupture dynamics, Modeling of deep and surface geology based on gravity survey, microtremors observation, and reflection survey, Development of nonlinear site response analysis considering liquefaction and/or large deformation.

2) Seismic Behavior of Structure System: Investigation of a dynamic performance of energy absorbing devices and earthquake-resistant structures, Realization of hybrid experimental systems for real scale structures, Development of seismic design method for soil-pile foundation systems.

3) Development of Innovative Structures: Elastic column accompanied with frictional damping, Development of damper to reduce sloshing for tanks, Unbonded bar reinforced concrete (RC) structure.


Experiments of dynamic response of RC piers

Structural Dynamics

The main theme of this laboratory is the improvement of seismic designs of buildings, including foundations. Fundamental studies have been carried out to elucidate the dynamic characteristics of building structures with various types of foundations. The main research subjects are as follows:

1) Towards the reduction of CO_2 emission: Prestressed glue laminated timber slab systems have been proposed and developed for high to medium-rise buildings. One of the advantages of this system is the reduction of the seismic design loads due to the use of light weight timbers. The slab deflection can be controlled by the prestress provided by Precast Concrete (PC) tendons.

2) Seismic design of reinforced concrete structures: Seismic performance of reinforced concrete frame structures has been studied using experiments and theory to establish rigorous performance based designs. The problems related to the scale effects have also been studied recently.

3) Soil-structure interaction: Soil-structure interaction during strong earthquakes for both shallow and pile foundations are being studied, with special attention to the local nonlinearity which is, the base friction and earth pressure.

4) Seismic design of pile foundations: Seismic performance of pile foundations in liquefied ground has been studied based on dynamic centrifuge tests and numerical analyses, to establish performance-based design.

Seismic loading tests on RC structural walls



Centrifuge test of soil-pile-structure system

14

Research Division of Earthquake Hazards

The Division of Earthquake Hazards is composed of three sections, Earthquake Source Mechanisms, Seismotectonics and Earthquake Resistant Structures.

Current studies on earthquake source mechanisms, complexities in the Earth's crust, and processes of tectonic strain accumulation, all contribute to the basic understanding of when and where earthquakes occur. These types of information can help improve the long-term forecasts of future earthquakes, as well as improve the evaluations of strong ground motions for damaging events in Japan and around the world. Considering these long-term estimates of earthquakes occurrence, it is important to improve the current construction technologies to protect lives and maintain a functioning society when large earthquakes occur. In order to minimize the earthquake damage, we are working on methods to evaluate weaknesses in existing buildings, earthquake retrofit technologies, and development of safe and functional construction materials.

This division is a part of the Seismic and Volcanic Hazards Mitigation Group and maintains research with the Research Center for Earthquake Prediction on long-term evaluations of earthquakes, with the Sakurajima Volcano Research Center on regional crustal studies which include volcanoes and with the Division of Earthquake Disaster Prevention on building damage in urban areas.

Members of the Division for Earthquake Hazards

Earthquake Resistant Structures

The research of this section concentrates on improving the seismic safety of buildings by examining the earthquake response characteristics and collapse behavior of structures, using both experimental and analytical approaches. Ongoing areas of investigation are as follows:

1) Mechanical Properties of Structural Members and Frames: Studies are done on the safety limits of steel structures subjected to extremely large deformations. The behavior of column bases and their effects on collapse are examined and the deformation capacity and failure mechanism of composite floor slabs are studied.
2) Simulation of Earthquake Responses of Structures: Hybrid tests are carried out using combined quasi-static tests and numerical analyses. These include, substructuring hybrid test for simulation of large structural systems and real-time hybrid testing.
3) Advancement of Seismic Design Methodologies: Seismic retrofit techniques in coordinated design-construction and seismic design of structures using passive damping devices are developed.

Dynamic fracture experiment of beam-to-column joint in a steel structure

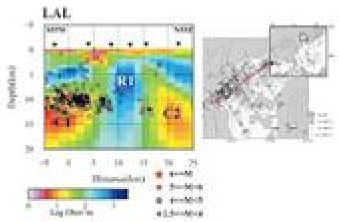
Collapse experiment of actual-size steel structure

15

Seismotectonics

Using methods from a variety of geophysical fields, such as geoelectromagnetism, geodesy and seismology, inhomogeneities in the earth's crust, earthquake source mechanisms, and earthquake preparation processes are investigated to improve the understanding and evaluation of long-term earthquake occurrences. In particular, studies are conducted to investigate the heterogeneous structures in the regions of the subduction plate boundary and the lower crust of inland areas. The results of these studies help clarify the regional stress accumulation process. Recent investigations include,

1) Studies of crustal heterogeneity around earthquake source regions and active faults to improve long-term evaluations of earthquake occurrence.
2) Studies of the regional and global conductivity structure of the Earth's interior.
3) Studies of the recovery process of the Nojima fault following the Kobe earthquake, using water injection experiments.

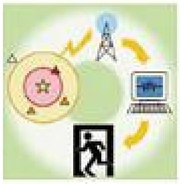


Resistivity structure to a depth of 20km in the region of the 2007 Noto Peninsula Earthquake (Mw6.7). Aftershocks are shown by the black circles in the cross section on the left and the map view on the right.


Deployment of ocean bottom electromagnetometers for investigating the resistivity structure offshore of Tottori prefecture in the Sea of Japan.

Earthquake Source Mechanisms

This section studies the physical mechanisms of earthquakes to provide a better understanding of seismic damage and advance efforts in earthquake prediction. We carry out field studies following large earthquakes and analyze a wide range of seismic data. Current research focuses on earthquake triggering studies, fault zone temperature monitoring, and seismic interferometry measurements.



We are also working on developing systems that provide fast information for early warning of strong shaking during large earthquakes.


11 meter fault scarp from the 2008 Wenchuan, China earthquake

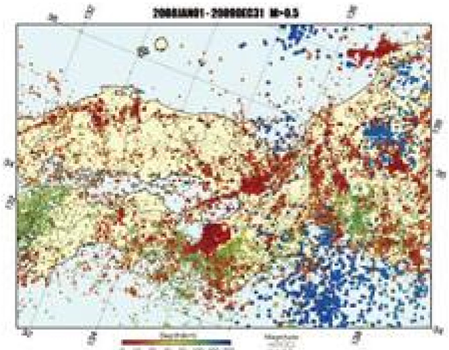

Severe building damage in the town of Onna from the 2009 L'Aquila, Italy earthquake

Research Center for Earthquake Prediction

The Research Center for Earthquake Prediction (RCEP) carries out many aspects of seismic research related to earthquake sources, seismic velocity structures, distributions of earthquakes in southwest Japan and laboratory investigations. These studies contribute to the ultimate goals of the earthquake prediction and mitigation of earthquake damage.

The RCEP has 7 research laboratories and 8 observatories. These sections cooperate with other sections of the Group for Seismic and Volcanic Hazard Mitigation, especially with the Division of Earthquake Hazard, in research and observational activities. The RCEP is also involved in collaborative projects with other universities and national institutes.

During the first half of this century, the probable occurrence of a great earthquake along the Nankai trough is reaching a peak; also large damaging inland earthquakes in southwest Japan appear to be occurring more frequently. In this active seismic period, the RCEP focuses its efforts into 3 main areas: Prediction of the next Nankai earthquake, Studies of inland earthquakes in southwest Japan and the outreach efforts for other disciplines and the public.

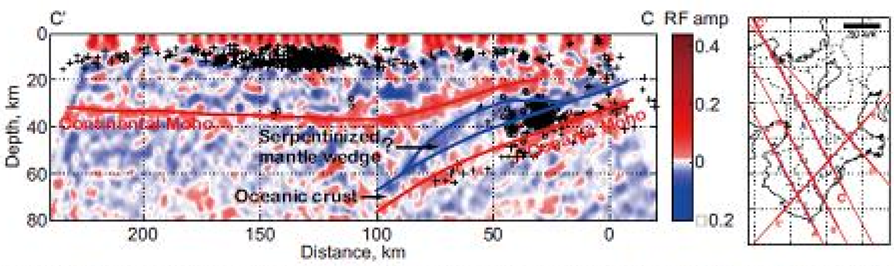


Epicenter distribution from 2008 to 2009 in southwest Japan after the hypocenter catalog integrated by JMA, which is including the data from the micro-earthquake observation system of the RCEP.

Crustal Activity Evaluation

Evaluation of crustal activity associated with geophysical processes of the Earth:

We detect, analyze and interpret the crustal activity by integrating seismic velocity structure from subduction plate boundaries to inland regions, the slip history of active faults, crustal movements measured by GPS and seismicity in the regions. We investigate the relationship between the geophysical processes and the occurrence of large earthquakes on the plate boundaries and in the inland regions, and finally derive a variety of information that is useful for predicting the generation of the large earthquakes and the strong motions.



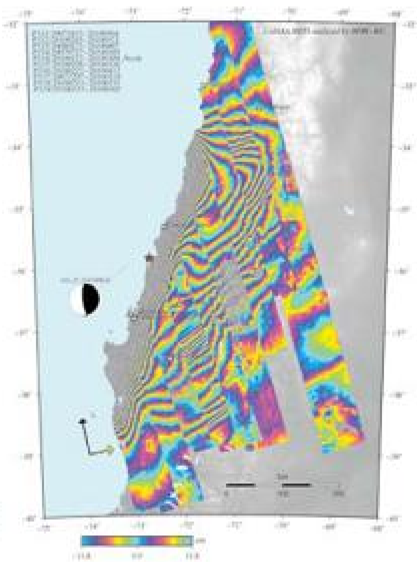
Receiver function (RF) image showing S wave velocity discontinuities in a cross section along the profile line CC' in the right map. The red (blue) lines are interpreted as the upper surface of high (low) velocity layers. The open circles and crosses denote low frequency earthquakes and ordinary earthquakes, respectively. The blue open circles in the map indicate the seismic stations used in the analysis.

Subduction Zone Earthquakes

Modeling of the generation process of subduction zone earthquake:

In order to promote the research on forecast of subduction zone earthquakes, we have been conducting studies of accumulation process of stress and strain in their source region using seismic and geodetic observations. Besides, the estimation and modeling of detailed structure around the plate boundary by means of seismic explorations have been done. Our goal is to develop an evaluation method of strain energy build-up process on the basis of the above results.

At present we focus on the study of coseismic and interseismic deformations in subduction zones with Synthetic Aperture Radar (SAR), GPS etc.



Interferogram of the coseismic deformation from the 2010 Chilean earthquake detected with ALOS/PALSAR

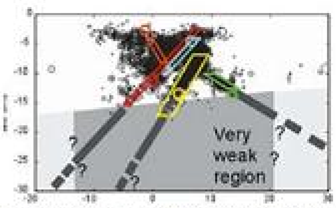
Inland Earthquakes

Research on the generation process of intraplate eartquake:

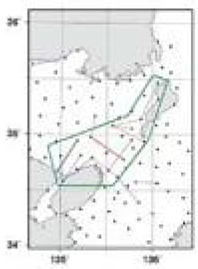
It is well known that seismic activities in the intraplate region in southwest Japan become high before a great plate boundary thrust earthquake along the Nankai trough. In order to reduce disasters by these intraplate earthquakes, we conduct researches to clarify the process by which intraplate earthquakes are generated, which is not well known at present, and to develop a new method of forecasting the occurrence of intraplate earthquakes.

Major research topics are as follows:

1) Stress accumulation process on intraplate earthquake faults resulting from heterogeneities in the lower crust.
2) Origin of the anomalous seismic activities and strain rates in the central Kinki district.
3) Dynamics and earthquake generation process in the Niigata-Kobe tectonic zone.
4) Anelastic deformation in the upper crust.
5) Development of new methods to infer precise locations of earthquake faults, and hypocenters and asperities of large earthquakes.



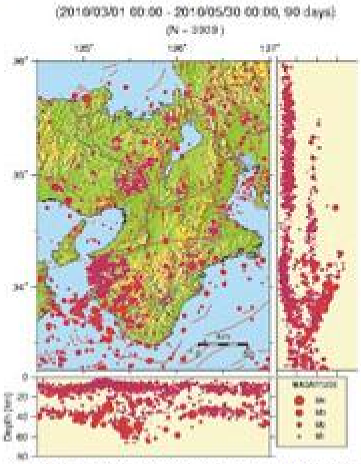
Earthquake faults of the Niigata-Chuetsu earthquake and heterogeneities in the lower crust



Deceleration of strain rate in the Kinki district (Red line indicates contracted baseline and blue line indicates extended line)

Crustal Activity Information

Assesment of information for earthquake prediction based on seismic and other geophysical data:



An example of earthquake information in the Kinki District, showing hypocenters automatically determined in recent three months

We have been constructing a database of seismic activity, crustal movement and other geophysical observations, through exchanging seismic data with other universities and national research agencies. Information for crustal activity and long-term earthquake prediction has been assessed based on the researches using the database; seismicity in southwest Japan, structural properties in the earthquake source area, space-time variation of earthquake generating properties. We also plan and execute basic surveys of tectonic structures and active faults.

Telemetry room, where data from observation networks for micro-earthquakes and crustal deformation are processed in real time

Earth Observation Systems

Development of observations and measurements in boreholes:

Developments of new experimental methods in the field and laboratory are being carried out. New methods applicable in boreholes near active faults, such as the Nojima fault, are being used to record and analysis various data, associated with earthquake occurrences, to clarify the preparation process of earthquakes.

The recent themes of this division are as follows:

1) Broadband hydroseismograms (pore pressure) monitoring by closed borehole wells to see the change of rock stress due to barometric pressure, earth tide, free oscillation and seismic events.

2) Monitoring AE events using hydrophone in to the borehole at active fault zone.

Pore pressure monitoring of borehole at the Kamioka mine

Integrated Real-time Systems

Monitoring of seismic process and seismic activity with integrated observations:

In situ and real-time observations of current crustal phenomena using various geophysical methods are carried out at the specified local area. Observation instruments are deployed temporarily, but with density higher than that of permanent observation networks for precise analyses.

The main research subjects are as follows:

1) Urgent observation for aftershocks of the large earthquakes.
2) Crustal structure survey using the artificial seismic sources.
3) The temporal observations with the dense seismic network in the specified local regions.
4) The temporal and/or periodical observations on geodetic and geoelectro-magnetic methods in the specified local regions.

Preparing mobile seismic recorders for a temporal seismic observation

Earth's Interior (Visiting Professor)

Studies of characteristics of the crust and mantle:

Studies on the mechanical and chemical characteristics of material in the crust and mantle are carried out to refine knowledge of the seismogenic environment. Also studies on the deformation and stress accumulation process at the subduction zone and the inland area. Risk evaluation on mega-earthquakes is also included.

Column Observatories of RCEP (Research Center for Earthquake Prediction)

The RCEP has 8 observatories, namely Kamitakara, Hokuriku, Abuyama, Tottori, Donzurubo, Osakayama Tokushima and Miyazaki Observatories. These observatories are important base stations to perform geophysical observations at each characteristic local area. However, significance and mission of these observatories are changing with time. Especially, recent progress on communication technologies altered the condition of the observation. Now, we are planning to rearrange the observation systems and the role of observatories.

Abuyama Observatory (Takatsuki, Osaka) and historical seismographs in exhibition room

Sakurajima Volcano Research Center

Several active volcanoes are located in the southern Kyushu and the Ryukyu islands. Sakurajima Volcano Research Center is the base of field observation and experimental research of these active volcanoes. Collaborative studies have been conducted with universities and institutions under the National Project of Prediction of Earthquakes and Volcanic Eruptions, the collaboration programs of DPRI and so on. One of the recent main topics is the seismic survey of the Aira caldera and Sakurajima using artificial explosions to investigate locations of magma storage and magma pathway. In addition, comparative studies of eruption mechanism have continued under international collaboration with Indonesia.

The 2007 lava dome of Kelud volcano, Indonesia

Sakurajima Volcano Observatory

Shot points and stations of seismic experiments in 2008 (left) and installation of OBS (right)

Prediction of Volcanic Eruptions

Eruptions of Sakurajima volcano have continued at the summit crater since 1955, and in 2006, the Showa crater on the east flank abruptly started eruption after dormant period of 60 years. The eruption process, the mechanism of volcanic explosions and the shallow magma system of the volcano has been studied using several kinds of data collected by seismometers, tilt and strain meters, infrasonic microphones, TV and infrared cameras and other geophysical and geochemical observations. Seismic and deformation data are practically used for the evaluation of short-term volcanic activity and the real-time prediction of volcanic explosions.

Observation network at the Sakurajima volcano

The tilt and strain observation in an underground tunnel, and tilt and strain records associated with an explosive eruption.

Explosive eruption at the Showa crater

21

Geohazards Research Group

Research Division of Geohazards

The Geohazards Division pursues the research for the prediction and mitigation of earth surface hazards based on the sciences of geophysics, geology, geotechnology, geomorphology, hydrology and environmental science and technology. The Division conducts interdisciplinary research by cooperating with other scientific disciplines. The geohazards under investigation include liquefaction, ground settlement, slope failure, landslide, soil erosion, slope or foundation deformation due to construction, groundwater problems, deformation or loss of special types of soil, severe surface erosion and deformation or collapse of underground caverns. Such hazards can be affected by acidification of soils by acid rain, acid soil, waste disposal and waste recycling, as well as other land management practices. Research on geohazards is conducted in mountainous and hilly terrain, flat land, coastal areas, and the sea bottom. These areas are increasingly affected by the expansion of human activities. Research in this division focuses on the generation and the behavior of geohazards and the methodology of hazard mapping, incorporating sophisticated basic scientific research and technology and cooperative interdisciplinary research within and outside DPRI.

Failure of a tailings dam in Las Palmas, Chile, after the 2010 Chile earthquake

Geotechnics

Rapid development of urban areas originated from plains and lowlands towards hills in the suburbs poses increasing risks in geohazards. The potential geohazards include soil liquefaction during earthquakes, settlement of reclaimed lands, collapse of artificial cut-and-fill including cultural properties such as ancient tombs, and slope instability. A series of strategic measures are required for mitigating these geohazards and establishing higher performance of geotechnical works. Various approaches are adopted for achieving these objectives, such as nonlinear effective stress analysis of soil-structure systems constructed on saturated sandy deposits, global modeling of geohazards based on the use of GIS and urban geo-database, experimental studies through geotechnical centrifuge and advanced laboratory test equipment. Currently, our research topics include:

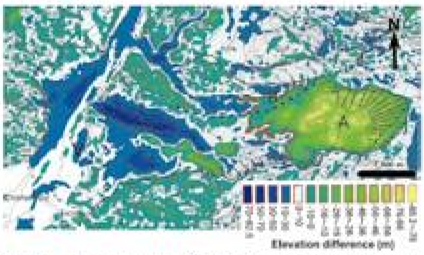
1) Study on the static/dynamic mechanics of large deformation of the ground.
2) Development and application of ground improve methods.
3) Study on interaction between foundation and structure using geotechnical centrifuge model tests.
4) Study on mechanisms on and remedial measures for ground softening during earthquake.
5) Prediction of deformation in the foundation-structure system and establishment of rational design method.
6) Development of geotechnical conservation methods for cultural properties.

Damaged road embankment at the river mouth of the Rio Tubul after the 2010 Chile earthquake

Mountain Hazards

Mountainous areas are susceptible to mass movement hazards because of their high altitude and steep slopes. We have been studying the following issues to evaluate and mitigate mountain hazards, which are long-term geological phenomena as well as short-term mechanical phenomena.

1) Deep-seated gravitational slope deformation and large-scale landslide.
2) The mechanisms and rates of rock weathering, which is a basic cause of shallow landslide.
3) Interaction between hydrological processes and geological and geomorphological conditions.
4) Hazard mapping methodology in mountainous areas from the view points of geology and geomorphology.
5) Optimum land usage in mountainous areas for the prevention and mitigation of mountainous disasters.



Elevation change by the Shiaolin landslide induced by the typhoon Morakot in Taiwan 2009. Debris from the source areas A and B attacked the village (V) and killed 318 people.

Gravitational slope deformation in the Akaishi Mountains. Numerous number of linear depressions were identified by using the high-resolution DEM obtained by the air-borne laser scanner.

Slope Conservation

Land use changes in Japan and throughout Asia have contributed to the severity of sediment and hydrogeomorphic hazards. Recent development activities in and around steep slopes have resulted in greater damage by mass movements and water. Vegetation conversion and roads on hillslopes also strongly influence these hydrogeomorphic processes.

To address these issues, the following studies are underway:

1) Landslide prediction, hazard mapping, assessment and modeling in sloping urban areas and in steep catchments subject to vegetation cover change.
2) Investigations of stormflow generation pathways and related hydrogeomorphic processes in headwate catchments.
3) Evaluation of the effects of distributed land uses and roads throughout Asia on sediment sources, pathways, and downstream impacts.

A pipeflow exposed at the head scarp of the landslide is believed to cause slope instability

Shallow landslide in the granitic area of Hofu city by a heavy rain storm on 21 July, 2009

Research Center on Landslides

The Research Center on Landslides (RCL) was established in 2003. RCL aims to pursue research for protecting human lives, properties, and cultural and natural heritage from landslides. RCL conducts research on mechanisms of initiation and motion of landslides triggered by earthquakes, rainstorms, etc risk assessment of rapid and long run-out landslides, the development of precise monitoring systems of landslides at local to global scales, failures in urban fill materials, anthropogenic factors and new techniques of landslide field / laboratory investigation and instrumentation. Education and capacity building for landslide risk mitigation are also important tasks of RCL. RCL has two research sections, Landslide Dynamics and Landslide Monitoring.

Landslide triggered by the 2008 Iwate-Miyagi Nairiku earthquake

Landslide cross section found in the archaeological site: This landslide was induced by the 1596 Keicho-Fushimi earthquake.

Landslide Dynamics

Rapid and long traveling landslides triggered by earthquakes and rainstorms, especially those in urban areas, have caused catastrophic disasters. To promote science and technology for landslide risk evaluation and mitigation especially for those catastrophic landslides, new geotechnical testing apparatuses including dynamic loading ring shear apparatuses have been developed. Techniques for landslide hazard mitigation are also studied. Current major research topics include:

1) Studies of Landslide Mechanisms.

- Initiation and runout mechanisms of fluidized landslides triggered by earthquakes and heavy rains and state-shift from slide to flow.
- Creep movement mechanism of landslides.

2) Development of Testing Apparatuses, Remote Sensing and Exploration Techniques.

- Geotechnical testing apparatuses for landslide studies.
- Application of satellite- and air-borne remote sensing data and data-transfer from remote stations and ground water exploration.

3) Mitigation of Landslide Hazards.

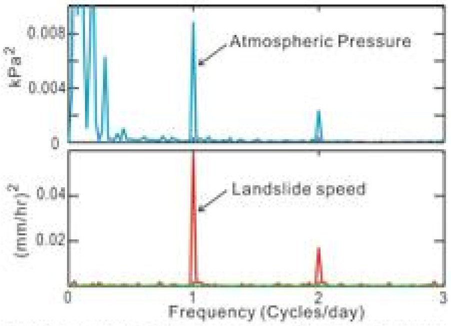
- Cultural and natural heritages at landslide risk.
- Evaluation and management of landslide risk.
- Prediction of landslide occurrence time.
- Stability analysis of landslide dams.

Ring shear apparatus for simulating landslides triggered by earthquakes and heavy rainfalls

Landslide Monitoring (including the Tokushima Landslide Observatory)

The section includes the Tokushima Landslide Observatory located in Tokushima Prefecture, one of most landslide prone areas in Japan as a field base. Technologies for the monitoring of landslide movement and triggering factors, the measurement of mechanical and physical landslide parameters are developed. Field investigations of various types of landslides occurring in Japan and foreign countries, education and capacity building for students and researchers from foreign countries are conducted.

Tokushima Landslide Observatory



Air tides and landsliding: power spectra of atmospheric pressure and landslide speed for Slumgullion landslide, Colorado, USA

Column Annual Events

- **DPRI Annual Meeting**
  A scientific meeting for reporting results of disaster research is held in late-February each year which includes both poster and oral presentations. Recent disasters are reported along with current research of DPRI faculty and graduate students in the areas of integrated disaster management, earthquakes, volcanology, geohazards, water-related disasters and atmospheric hazards.
- **DPRI Open Campus**
  An event for people interested in learning about the education and research programs of Kyoto University (in late-September each year). DPRI staff gives a demonstration of an impact resistant test of cladding by windbornemissile by an air-cannon.
- **DPRI Open Lecture**
  Selected lectures given in September each year by DPRI staff to publicize their research and outreach activities. These provide local citizens with opportunities to learn about DPRI research and outreach that may be related to their work and living.

Atmosphere-Hydrosphere Research Group

Research Division of Atmospheric and Hydrospheric Disasters

This division pursues establishment of scientific principles to mitigate atmospheric and hydrospheric disasters. Five research sections exist in which researchers in meteorology, hydrology, architecture and coastal engineering collaborate in studies on atmospheric and hydrospheric hazards at various spatial and temporal scales. The spatial scale of the events ranges from the size of humans and buildings to urban, regional and global scales. Typhoons are one of the typical research subjects in this division. Meteorologists investigate the nature and the predictability of typhoons. Storm surges, high waves and associated disasters are studied by coastal researchers. Hydrologists predict heavy rain, river discharge, and floods. Strong wind damages are predicted and estimated by architectural researchers. In addition to severe ephemeral events, relatively modest events like atmospheric blocking are also studied. We are extending our studies to include projections of atmospheric and hydrological impact assessment in future global warming scenarios.

Atmospheric and Hydrospheric Research Division consists of five research sections studying climate environment, severe storm and atmospheric environment, wind disasters and maritime disasters, as well as hydrometeorological disasters.

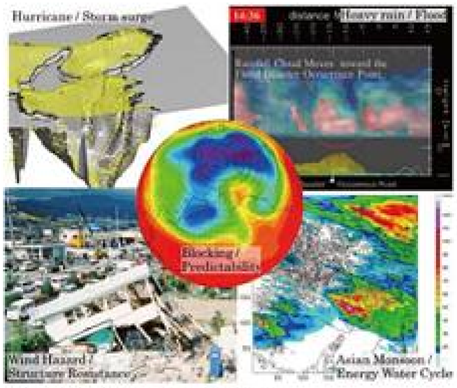
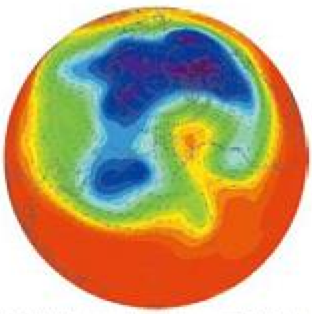


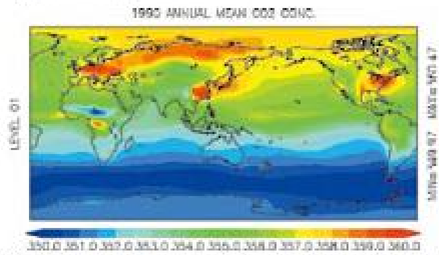
Image of research topics of this division

Climate Environment

In order to elucidate the mechanism and the predictability of anomalous weather and climate change, we are conducting numerical experiments using general circulation models and regional atmospheric models. We are also analyzing several kinds of atmospheric datasets, such as long-term global reanalysis datasets and numerical weather prediction datasets. Recent major research subjects are:


Atmospheric blocking over Alaska occurred in February 1989

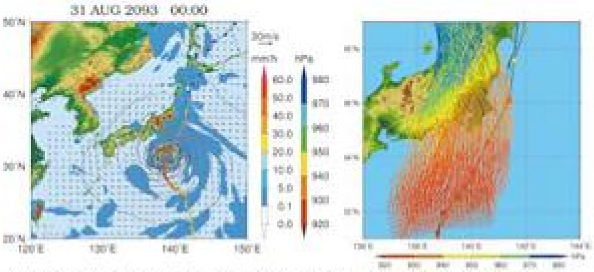
1) Dynamics and predictability of large-scale atmospheric motions.
2) Stratospheric influence on dynamics and predictability of tropospheric large-scale motions.
3) Mutual interaction between extratropical weather regimes and large-scale motions in the tropics.
4) Development of a new method to obtain initial perturbations for the ensemble numerical prediction.
5) Atmospheric minor constituents and their effects on global and regional climate.



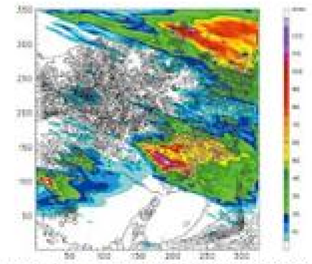
1990 annual mean surface CO2 distribution simulated by atmospheric transport model

Severe Storm and Atmospheric Environment

This section conducts a wide range of meteorological researches on extreme weather and environmental atmosphere that have spatial scales ranging from microscales to mesoscales, regional-scales and up to continental-scales. This section specifically focuses on understanding the dynamics and mechanisms of extreme weather such as heavy rainfall and strong wind due to typhoons, extratropical cyclones, convective storms, tornadoes and boundary-layer turbulence. We also investigate the fundamental processes of atmospheric turbulence, boundary-layer phenomena and mesoscale disturbances that spawn extreme weather. Our research extends to the investigations for the Asian monsoon water cycle and also the extreme weather characteristics in future global-warming climates. For these purposes, we conduct in-situ observations, satellite-data analyses, meteorological data analyses, and numerical modeling and simulations. By combining the various research tools, this section advances current understandings on severe storms and atmospheric environments.



Investigation of extremely hazardous typhoon. The most hazardous path is searched with PV Bogusing.



Meteorological simulation of the Toga River heavy rainfall in July 2008

Wind Engineering and Wind Resistant Structures

This section supports research on various subjects related to the wind resistance performance of structures and the wind environment around buildings and structures. These studies are carried out using wind induced hazards analyses, field observations, wind tunnel tests, numerical simulations and other methods. The research topics of the section are as follows :

1) Wind resistant design to improve performance of buildings and structures.
2) Damage of buildings and structures induced by strong winds.
3) Wind induced forces and vibration of buildings.
4) Wind pressure on claddings.
5) Study on impact resistant test against windborne debris for glass.
6) Prediction of wind characteristics in cities and wind environment around buildings and structures.
7) Numerical investigation of wind characteristics in the tornadoes.

Collapsed houses in Nobeoka city induced by tornado on 19th September 2006

Wind tunnel test for wind pressure and velocity around tall buildings.

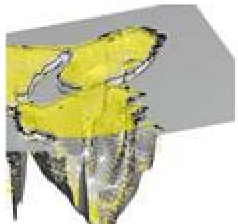
Impact test to glass by flying debris

Maritime Disasters

Extreme natural phenomena, such as tsunamis, storm surges and extreme ocean waves cause coastal disasters. For the purposes of protecting coastal areas, we develop and improve physics and numerical models of these phenomena and investigate design methods of coastal structures against the extreme forces. Moreover, global warming effects on climate change, sea level rises and magnitude of typhoons are expected to increase the coastal disasters. Such climate influences on coastal environment are also important subjects for us. Our current research subjects are as follows:

1) Extreme wave and storm surge modeling.
2) Momentum transfer and mixing at upper ocean for improvement of wave and storm surge modeling.
3) Modeling of nearshore random waves and wave induced currents and resulting beach deformation.
4) Statistical analysis of damage characteristics of coastal structures, and their reliability and performance based design.
5) Development of real-time prediction of tsunamis.
6) Projection of extreme storm surges and waves in future climate under the global warming.

Coastal damage by storm surge and waves



Storm surge and coastal current modeling

Hydrometeorological Disasters

This section supports research on the phenomena analysis and model buildings focusing on human activities and the interaction between the atmosphere and the hydrosphere. Research topics carried out presently and started in a few years are as follows:

1) Evaluation of basinwide hydrological disasters' variation based on the climate change in 21st century.
2) Development of precipitation forecasting methods using observation data by the latest polarimetric weather radar.
3) Physically-based analysis of torrential rainfall events considering basin characteristics.
4) Analysis of relationship among rainfall distribution, topographical laws of river basin and rainfall runoff mechanisms and evaluation of effects on the accuracy of flood prediction by distributed rainfall information.
5) Analysis of worldwide rainfall characteristics using observation data by meteorological satellites, and development of the application method to the flood prediction.
6) Analysis of the occurrence characteristic of extreme rainfall events in the world and concept making for the abnormal rainfall events corresponding to the basin characteristic and the human life sphere, taking global warming into consideration.
7) Analysis and estimation of pollutant runoff mechanisms including atmospheric phenomena, land surface and groundwater system for evaluation and conservation of the water environment.
8) Planning and management of runoff mitigation facilities in urban areas for the inundation prevention, the efficient water utilization and water environment conservation, by application of radar information to analysis and prediction of the pollutant circulation.

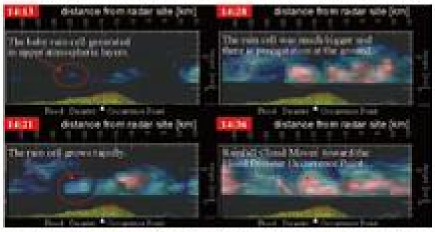
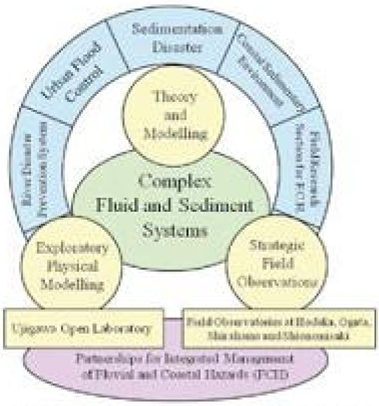


Image of torrential rainfall occurring in Kobe city in 2008: Original data was observed by Miyama radar of the Ministry of Land, Infrastructure and Transportation.

Research Center for Fluvial and Coastal Disasters

The Research Center has two missions. First of all, it promotes in-depth studies of fluid and sediment processes that may bring about serious disasters and environmental changes, frequently through chain reactions, to watersheds, reaches, reservoirs, estuaries and coastal oceans. These studies are inherently interdisciplinary and are covered by the Center's five research sections: Sedimentation Disasters; River Disaster Prevention System; Urban Flood Control; Coastal Sedimentary Environment; and the Field Research Section for Fluvial and Coastal Hazards. Secondly, yet equally important, the Center's unique facilities are open to the partners for field and experimental studies on disaster prevention and environmental preservation in the river-coast system. The attached Ujigawa Open Laboratory, one of the largest experimental stations in Japan, is dedicated for experimental research that focuses on the dynamics of fluvial, estuarine and coastal hazards. Such experimental studies have a close relation with observational studies that have been conducted at the Center's four field stations. With these facilities actively promoting collaborative research, the academic staff at the Center has developed cutting-edge technology for predicting complex processes in the hydrosphere, together with disaster reduction methodology.



Research Center for Fluvial and Coastal Disasters – A perspective

Sedimentation Disasters

In a sediment transport system from mountainous area to coastal area, disasters occur due to the various kinds of sediment transport phenomena. These sediment transport phenomena triggered by natural causes as well as by human activities also impact on ecosystem within the sediment transport system. To mitigate the disasters and to understand the dynamics of sediment transport and water – sediment – ecosystem structure in the sediment transport system, various field observations, hydraulic experiments, and development of simulation models are carried out in our division.

Major research themes are:

1) Monitoring and predicting the sediment dynamics in the sediment transport system.
2) Improving precision of prediction for sedimentation disaster occurrence.
3) Understanding the water – sediment – ecosystem structure.
4) Comprehensive sediment control within the sediment transport systems.


Sediment disaster in Taiwan


Bank erosion at the Sesayap River in Indonesia

Urban Flood Control

Unexpected disasters may occur in highly developed urban areas. In this section, we study fluvial and marine disasters in urban areas. We develop numerical simulation models related to urban flood disasters. We also execute hydraulic experiments on evacuation in flooding.

Real-scale experiment apparatus of the evacuation from a submerged car

The main research topics are as follows:

1) Mechanism of urban flood disasters due to heavy rainfall, river flood, storm surge, tsunami or their combination.
2) Numerical modeling and analysis of inundation flow behavior in urban area considering underground space.
3) Design and evaluation of both structural countermeasures (such as underground tunnel systems) and nonstructural ones (such as evacuation systems).

3D numerical simulation for the inundation process of an underground space

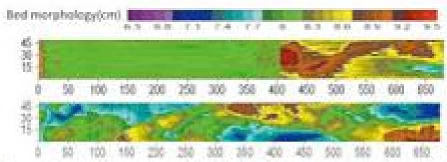
River Disaster Prevention System

It is necessary to understand hydraulic mechanisms and sediment flow behavior, in order to establish a prevention/mitigation system of flood and sediment disasters over a whole river basin, and to create river recreation space considering ecological environment and landscapes. We are studying many prediction methods and useful strategies on the above objectives, based on flume experiments, field observations and numerical simulations.

The main topics are as follows:

1) Mechanisms and prevention/mitigation schemes of river and sediment disasters.
2) Strength evaluation and maintenance methods of river disaster prevention facilities such as river dykes.
3) Collapsing mechanism of natural dams and glacial lakes.
4) Riverbed deformation around river structures.
5) Simulation of riverbed deformation of mixed sediment diameter.
6) Stabilization of continental fluvial river channel.
7) Flow structure and topography variation around river mouth and estuaries.
8) Field survey on flood and sediment disasters.

Field measurement at the Jamuna River

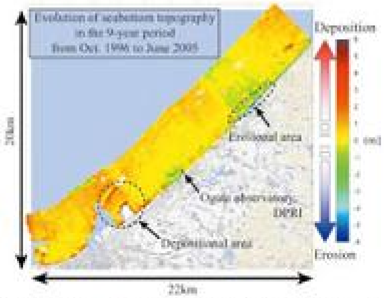


Experimental results of river bed deformation due to weir improvement

Coastal Sedimentary Environment

This research section promotes studies of coastal disaster prevention related to sedimentation and environments. For example, beach erosion due to wave and current action is generated by imbalance between incoming and outgoing sedimentation volumes in a target coast. Physical and analytical survey on the coastal sediments is necessary to maintain the coastal topography reduce the tsunami and storm surge energy as well as stormy waves. The ongoing research projects include the following:

1) Analysis of echo sounding results on sea bed by means of GIS.
2) Identification of flood-related sedimentary features for floodplain management.
3) Prevention of scouring around maritime facilities due to tsunamis and sea waves.
4) Survey on effect of coastal vegetation and groundwater to beach erosion.
5) Mechanism of river channel erosion due to fast flow.



Estimated sea bed topographical changes in Joetsu Coast


Survey on pumping of sediments and diameter distribution


River channel erosion due to flow discharge

Field Research Section for Fluvial and Coastal Hazards

The mission of this section is to perform continuous field observations on meteorological, fluvial and hydrodynamic issues, related to the disasters in the atmosphere and hydrosphere. This section includes four observational facilities, namely Shionomisaki Wind Effect Laboratory, Shirahama Oceanographic Observatory, Hodaka Sedimentation Observatory and Ogata Wave Observatory. These facilities are open to the research communities and widely used for the field study, education and training. The observational results describe the real behavior of atmospheric and hydrospheric disasters and clarify their mechanisms. In addition the results are utilized to develop numerical simulations and forecasting models. The current major research themes are as follows.

1) Observational research on the water, energy and material transport and circulation.
2) Integrated observation of disasters and environmental changes.
3) Development of measurement techniques for atmospheric, hydraulic and environmental factors.
4) Development of integrated models for forecasting atmospheric and hydrospheric disasters.


Field study on sediment production from Hiru-dani bare slope (Hodaka)


Field measurements by freshman students on a ship "Kaisho" (Shirahama)

31

Column

Observatories of Research Center for Fluvial and Coastal Disasters

Ujigawa Open Laboratory (Fushimi, Kyoto) is renowned as one of the leading experimental laboratories in the world, and many observation and experimental facilities for hydraulic and sedimentation research are installed. Those facilities are used not only for the internal research, but for education, national and international academic cooperation and cooperative research with industries and governments. Additionally, simulated disaster experiences for the public are carried out with the help of the technical staff.

Experimental halls and flood channel facility (Ujigawa Open Laboratory)

Shionomisaki Wind Effect Laboratory (Kushimoto, Wakayama) is located on the southern end of the main island of Japan with a test field of 4,000 m² range. The main research topics are the characteristics of high winds and heavy rainfalls, and their effects to the structures in the natural wind during the extreme events such as typhoons, tornadoes and winter monsoon. Turbulent structure in the high wind and the transport mechanism of the energy flux in the atmospheric boundary layer are also studied.

Research building with wind tower (Shionomisaki Wind Effect Laboratory)

Hodaka Sedimentation Observatory (Takayama, Gifu) has its main study area in the Gamata River including active volcano Mt. Yake in the Hida mountain range. We investigate atmospheric and hydrological factors such as precipitation, snowfall, air temperature, water runoff, and sediment related factors such as sediment yield, turbidity, sediment runoff, bed variation, and environmental factors such as habitat of aquatic creatures. We also develop various technical methods such as bed load measurement or sediment flushing from reservoir.

Main building with Mt. Kasagadake in the background (Hodaka Sedimentation Observatory)

Ogata Wave Observatory (Joetsu, Niigata) was established in 1969 at the Joetsu coast. In 1986, an observation pier with T-shape was constructed and the field study on stormy waves and strong near-shore currents has been carried out until 2008. Currently sediment budget analysis in coastal zone is mainly studied in echo-sounding of seabed, core-sampling of coastal dune and so on.

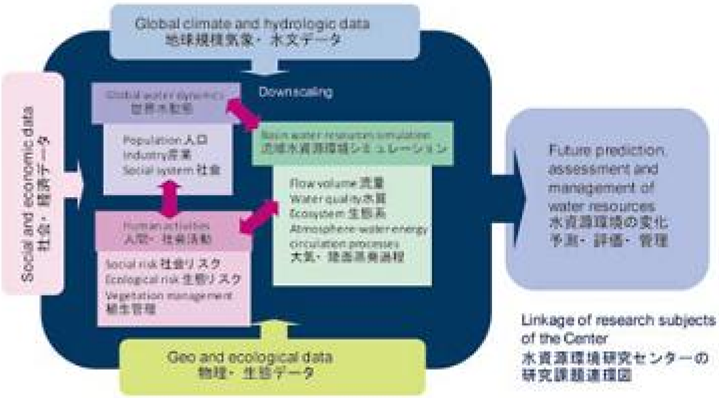
Main building (Ogata Wave Observatory)

Shirahama Oceanographic Observatory (Shirahama, Wakayama) has a fixed-point tower in the mouth of Tanabe Bay and a ship "Kaisho" of 12 m long, 3.4 ton for real-time observations of the oceanographic phenomena. The mechanisms of wave-tide characteristics, air-sea interaction and river-coast-sea systems are investigated in relation to disaster mitigation and environmental preservation in the coastal area.

Tanabe-Nakashima oceanographic observation tower (Shirahama Oceanographic Observatory)

Water Resources Research Center

The Center investigates the complete water resources management system, including conservation and development of water resources as integrated elements of geosystems, social systems and ecosystems. In particular, analysis of the effect of human social and economical activities on the hydrological cycle is undertaken along with development of water environment dynamics models which can comprehensively simulate various aspects of water resources such as water quantity, quality, and ecology. Social and ecological risk management of water resources, and technologies and systems for water disaster mitigation are also investigated.

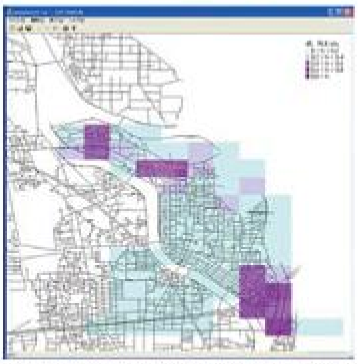


Linkage of research subjects of the Center

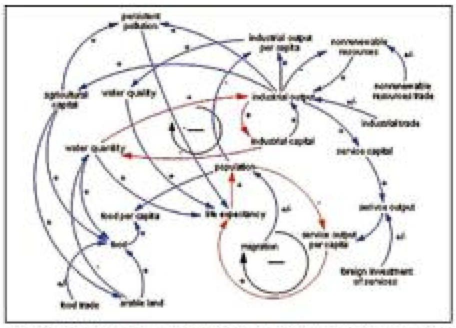
Global Water Dynamics

The research is focused on the analyses of interaction among global water dynamics and human activities seeking solutions for water resources problems. The current research topics are development of global water dynamics model including social and economic activities, and long-term reservoir operation based on global meteorological and hydrological information.

Additionally, in order to develop prevention and mitigation system of water-related hazards, which will be worsening as a result of global change, regional preparedness and human response to floods and droughts are also investigated.



Flood evacuation model considering mental attitude to risk and detailed field information

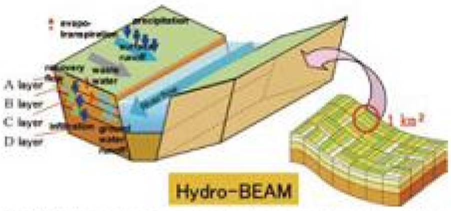


Global water dynamics model considering social and economic activities

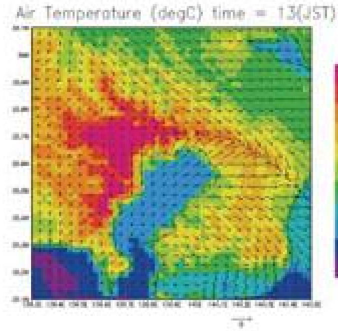
33

Regional Water Environment System

Based on the three dimensional hydrological cycle model linking atmosphere, surface water, and ground water, comprehensive environment dynamics model considering the effects of regional development, water use, and pollutant release is being developed. The concept of integrated water resources management harmonizing with water environment/culture is proposed. Many studies related to global warming issues are in progress such as detection and correction of climate model biases, future projection of urban climate, statistical downscaling of global warming projection information, assessing the impact of climate change on flood and drought, etc.



Distributed river basin environment assessment model (Hydro-BEAM)



Assessment of urban climate by urban canopy model

Socio and Eco Environment Risk Management

In order to solve long term environmental problems in the water resources issues, influences of geo-, eco- and socio-system changes on water resources systems are analyzed from the aspect of risk management. Measures for integrated river basin management of flood control, water use and environmental conservation are investigated to enjoy sustainable ecosystem services. We focus on 3 subjects such as: asset management of dams and development of reservoir sediment management methods, model development of eco-sediment hydraulics by habitat structure analysis and interactions between human use and ecosystem responses in water front environments.

Linkage of tackled research topics

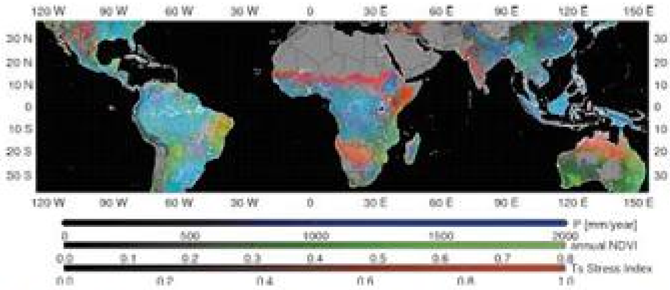
Sediment flushing of Unazuki dam, Kurobe River

Water Resources Distribution Assessment (Visiting Professor)

Extramural researchers are invited to this research field in order to provide knowledge and techniques for analysis of water, heat, material circulation systems, evaluation, planning, and management of water resources systems for the human society co-existing with nature, and to tackle the current issues which is socially demanded to solve. The current research topics are as follows:

1) Investigation of legal systems such as laws of public properties, water laws and those of terrestrial water, for the development of more implementable water resources planning and management considering consistencies with social systems.

2) Observation and analysis of land surface processes through remote sensing by satellites for the clarification of global hydrologic circulation and water dynamics, introduction and investigation of phenology for the model elaboration of land surface processes in hydrologic circulation.



Global map of RGB composite image representing rainfall - vegetation Index (NDVI) - surface stress index's interaction

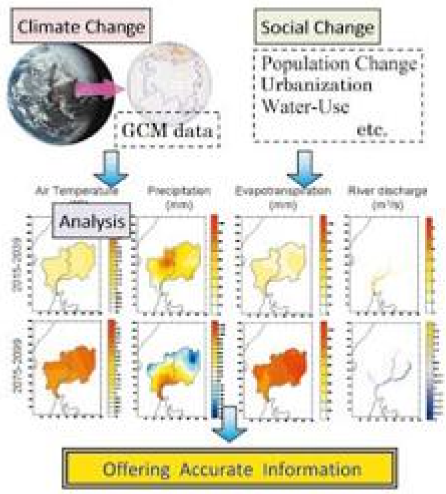
Hydrologic Environment Systems (sponsored by JWA)

Hydrologic Environment System (Japan Weather Association) intends to clarify mechanisms of environmental issues and disasters associated with hydrologic cycle, and considers how the society should adapt to the climate change and the social changes. Our research focuses on the following topics:

1) Developing applied use of hydro-meteorological observation and prediction for water resources management, hydro-environmental management and countermeasures to water-related disasters.

2) Analyzing effects of climate change and social dynamics on water environment, industries (such as agriculture, forestry and fishery), energy environment, and health, medical and sanitary environment in urban and local living areas; investigation of new scenarios of hydro-environmental disaster based on such effects.

3) Developing downscaling methods that utilize outputs of climate change prediction models and social dynamics for impact assessments on urban and local living area and developing database for the impact assessment.



Impact assessment of climate change

Division of Technical Affairs

One of the unique characteristics of DPRI is that it has a number of experimental facilities and some special experimental equipment, as well as many observational or experimental remote facilities such as the Sakurajima Volcano Observatory, which is the southernmost.

The Division of Technical Affairs was established in 1996 by gathering technicians, who had been belonging to each Research Division/Center. The division provides various technical supports for operation, development and improvement of these experimental/observational equipments, as well as maintenance and management of these, in order to help staffs smoothly perform education and research.

The division operates and maintains the information and communication systems through information networks, strengthens the information security operation and maintains electronic mailing systems, homepages and database management systems in order to assist information dissemination of DPRI as a whole.

The division consists of four sections, whose roles are as follows:

Planning and Information Section

- Assist technical aspects in public relation and information dissemination of DPRI.
- Ensure, maintain and manage information security of computer and network systems.

Device Development Section

- Design, develop and improve measuring instruments and various devices for the various observations.
- Assist faculties and students to use safely various machines on a workshop.

Machine Operation Section

- Maintain, manage and operate observation systems and experimental machines and equipments.

Observation Section

- Install and maintain temporary and regularity observation stations, to maintain experimental stations.
- Support technical matters in observation, experiment and measurement.

At present the division has 29 technicians with 13 on the Uji campus and 16 at observatories and experimental stations.


Set up an electromagnetic survey system


Restored Rebeur-Paschwitz Tiltmeter of the 19th century


Development devise in a workshop


Experiment for hydrostatic pressure on a door caused by flood


Operation and maintenance information and communication systems


Vibration test of soil by a three dimensional shaking table

Sustainability/Survivability Science for a Resilient Society Adaptable to Extreme Weather Conditions

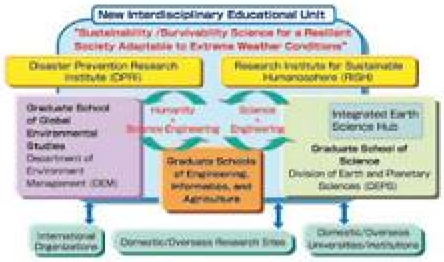
One of the most urgent global issues of our time is to cope with the impacts of the clearly recognized climatic changes, and associated extreme weather and water-related hazards, such as floods and droughts. Even if we were to immediately stop the present increase of emissions of greenhouse effect gases (e.g., carbon dioxide), it is impossible to curtail the detrimental outcome on our global climate. The lasting effects from our present industrial activities will continue for several decades.

At Kyoto University, in order to confront these crucial problems, we hope to provide more innovative education by creating a new interdisciplinary graduate school education system (Educational Unit) through the COE program. This effort will produce young world leaders from many countries, who will have the expertise to deal with the global climate issues in the coming decades.

The Educational Unit is composed of five graduate schools (Global Environmental Studies, Science, Engineering, Informatics and Agriculture) and two research institutes: Disaster Prevention Research Institute (DPRI) and Research Institute for Sustainable Humanosphere (RISH).

The Educational Unit consists of two interdisciplinary courses:Science-Engineering (SE) Joint Course and Liberal Arts and Science-Engineering (LASE) Joint Course. These Joint Courses are created because the global issues cannot be adequately addressed by researchers working in single disciplines. Viable solutions need a sound scientific basis, along with appropriate engineering considerations, as well as human-based, community-based and socially relevant considerations. It is necessary to train researchers with technical specialties and at the same time develop wider perspectives that cover interdisciplinary aspects. In other words, we need specialists in individual scientific disciplines with the view of "generalists".

We want to invite eligible personnel from the low-latitude regions to Kyoto, who can study at Kyoto University and continue research after returning to their own countries. If we keep in contact with them, we can provide useful suggestions when a new problem occurs in the future.



Outline of GCOE-ARS Educational Unit


Keynote speech by the Program Leader Professor Kaoru TAKARA


Welcome message by Kiyoshi YOSHIKAWA, Executive Vice President of Kyoto University


Group photograph of the inaugural symposium on January 13, 2010

Global Center for Education and Research on Human Security Engineering for Asian Megacities

Kyoto University has launched the Global Center Of Excellence (GCOE) Program in the Graduate School of Engineering, the Graduate School of Global Environmental Studies and Disaster Prevention Research Institute since 2008 fiscal year. In this five-year program, Kyoto University will establish a new discipline "urban human security engineering" and create a network of overseas bases for research and education on an Asian-wide scale to foster next generation researchers and high-level practitioners. Through this program, we will contribute greatly to solving human security issues in Asian megacities.

We define "Urban Human Security Engineering" as a system of technologies (techniques) for designing and managing cities that enable their inhabitants to live under better public health conditions, and also live free from potential threats of large-scale disasters and environmental destruction, as listed in the Millennium Development Goals. With this approach, we are developing the existing individual disciplines into a more comprehensive discipline that encompasses fields such as urban management strategies, urban policy in order to establish human security in Asian megacities, and promote research and education in this new discipline. More specifically, we will working together with universities, research institutions, and private enterprises in Asia through the network of seven overseas bases, and foster 20 doctoral students per academic year.

Four Major Disciplines of Human Security Engineering: DPRI is mainly contributing in the area of Disaster Risk Management

Special Symposium on Disaster Management for Human Security Engineering in Asian Megacities (Kyoto, 2009)

Kick Off Symposium in Mumbai Base (Mumbai, 2009)

Meeting with Officials in Municipal Corporation of Greater Mumbai (MCGM)

38

Academic Exchange Agreements

DPRI has academic exchange agreements with universities and research centers around the world, promoting interdisciplinary research prevention of natural disasters.

September 2010

Country/Region	University/Institute	Date of Agreement
Austria	International Institute for Applied Systems Analysis (IIASA)	May 16, 2000
Bangladesh	International Centre for Diarrheal Disease Research and Centre for Health and Population Research	December 9, 2002
	The Institute of Water and Flood Management, Bangladesh University of Engineering and Technology	January 28, 2004
Canada	The Institute for Catastrophic Loss Reduction	November 15, 2002
China	The Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences	September 20,1989
	The Institute of Tibetan Plateau Research, Chinese Academy of Sciences	June 26, 1996
	College of Resources Science & Technology, Beijing Normal University	May 31, 2004
	School of Civil Engineering, Southwest Jiaotong University	December 25, 2008
Egypt	The Faculty of Science, Assiut University	November 6, 2005
France	The United Nations Educational, Scientific and Cultural Organization	December 3, 1999
	International Consortium on Landslides, The United Nations Educational, Scientific and Cultural Organization	March 18, 2007
India	The Centre for Water Resources Development and Management	May 22, 2006
	Department of Geography, North Eastern Hill University	November 1, 2007
	School of Planning and Architecture, New Delhi	March 5, 2009
Indonesia	Geological Agency, Ministry of Energy and Mineral Resources of the Republic of Indonesia	July 2, 1993
	The JASA TIRTA 1 Public Corporation, Indonesia	November 28, 2003
Italy	Earth Sciences Department, University of Florence (Universita degli Studi di Firenze)	October 28, 2002
Nepal	Institute of Engineering, Tribhuvan University	November 29, 2002
Slovakia	Faculty of Natural Sciences, Comenius University in Bratislava	April 14, 2003
South Korea	The Professional Graduate School of Disaster Prevention Technology (PGSDPT), Kangwon National University	November 15, 2006
Taiwan	National Center for Research on Earthquake Engineering, National Applied Research Laboratories	November 19, 2004
	The Disaster Prevention Research Center, Cheng-Kung University	February 28, 2007
	Department of Civil Engineering, National Central University	April 23, 2010
	National Science and Technology Center for Disaster Reduction	May 30, 2010
U.S.A.	Pacific Earthquake Engineering Research Center	December 19, 2002
	The Southern California Earthquake Center	January 29, 2007
	The College of Atmospheric and Geographic Sciences, The University of Oklahoma	March 17, 2008
United Kingdom	The School of Applied Sciences, Northumbria University	May 15, 2007
Vietnam	Water Resources University	January 16, 2008

Organizations for Collaborative Research

Committee for Cooperative Research (CCR)

DPRI has served as a National Open Institute since 1996. Human resources, data and facilities of DPRI are open for use by external research collaborators. The CCR is an organization to coordinate nationwide cooperative programs for the purpose of natural disaster science and disaster reduction studies. Many joint projects are conducted between DPRI and external researchers throughout Japan.

Evacuation experiment through stairs in case of underground inundation

Ring shear apparatus to reproduce landsliding

Wind tunnel test using a city model

The shaking table experiment of a newly proposed seismic reinforcement technology for wooden houses

Major Facilities

Research Center for Earthquake Prediction

Abuyama Observatory
Donzurubo Observatory
Hokuriku Observatory
Kamitakara Observatory
Miyazaki Observatory
Osakayama Observatory
Tokushima Observatory
Tottori Observatory

Sakurajima Volcano Research Center

Sakurajima Volcanological Observatory

Research Center on Landslides

Tokushima Landslide Observatory

Research Center for Fluvial and Coastal Disasters

Ujigawa Open Laboratory
Shionomisaki Wind Effect Laboratory
Hodaka Sedimentation Observatory
Shirahama Oceanographic Observatory
Ogata Wave Observatory

Ousakayama Observatory

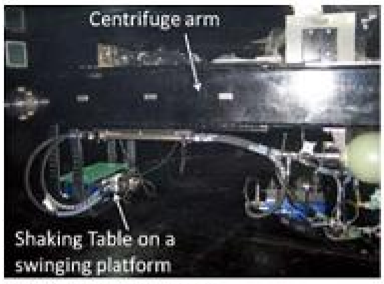
Miyazaki Observatory

Hokuriku Observatory

Abuyama Observatory

Tottori Observatory

Tokushima Landslide Observatory



Geotechnical centrifuge facility

40

Staff

September, 2010

[Director] OKADA Norio [Vice Directors] OSHIMAN Naoto, TAKARA Kaoru, TODA Keiichi

Research Group, Division and Center	Professor	Associate Professor	Assistant Professor
Integrated Arts and Sciences for Disaster Reduction Research Group			
Disaster Management for Safe and Secure Society			
Safety Control of Urban Space	KAWASE Hiroshi	MATSUSHIMA Shinichi	
Disaster Mitigation Planning for Built Environment	TANAKA Takeyoshi	SEKIGUCHI Haruko	
Innovative Disaster Prevention Technology and Policy Research	TAKARA Kaoru	YAMASHIKI Yosuke	
Social Systems for Disaster Risk Governance	TATANO Hirokazu	HATAYAMA Michinori	
International Research Collaboration for Disaster Management	*		
Public Policy Studies on Disaster Reduction (sponsored by JICE)	YASUDA Nario	KAJITANI Yoshio	
Research Center for Disaster Reduction Systems			
Integrated Disaster Reduction Systems	YAMORI Katsuya		SUZUKI Shingo
Disaster Information System	HAYASHI Haruo	MAKI Norio	
Disaster Risk Management	OKADA Norio	YOKOMATSU Muneta	
Historical Disaster Analysis	*	*	
Regional Disaster Studies	*	*	
Disaster Information Network	*		
Seismic and Volcanic Hazards Mitigation Research Group			
Research Division of Earthquake Disaster Prevention			
Strong Motion Seismology	IWATA Tomotaka	MATSUNAMI Koji	ASANO Kimiyuki
Dynamics of Foundation Structures	SAWADA Sumio	TAKAHASHI Yoshikazu	GOTO Hiroyuki
Structural Dynamics	TANAKA Hitoshi	TAMURA Shuji	
Research Division of Earthquake Hazards			
Earthquake Resistant Structures	NAKASHIMA Masayoshi		
Seismotectonics	OSHIMAN Naoto		YOSHIMURA Ryokei
Earthquake Source Mechanisms	MORI James Jiro	OMI Shiro	
Research Center for Earthquake Prediction			
Crustal Activity Evaluation	SHIBUTANI Takuo	TODA Shinji	XU Peiliang
			TAKADA Yoichiro
Subduction Zone Earthquakes	HASHIMOTO Manabu		FUKUSHIMA Yo
Inland Earthquakes	IIO Yoshihisa	FUKAHATA Yukitoshi	
Crustal Activity Information	NISHIGAMI Kin'ya	TAKEUCHI Fumiaki	KANO Yasuyuki
			TERAISHI Masahiro
Earth Observation Systems			MORII Wataru
Integrated Real-time Systems		KATAO Hiroshi	YAMAZAKI Kenichi
Earth's Interior	*		
Sakurajima Volcano Research Center			
Prediction of Volcanic Eruptions	ISHIHARA Kazuhiro	IGUCHI Masato	MIKI Daisuke
			YAMAMOTO Keigo
			TAMEGURI Takeshi

*Visiting Scholar

Research Group, Division and Center	Professor	Associate Professor	Assistant Professor
Geohazards Research Group			
Research Division of Geohazards			
Geotechnics	IAI Susumu	MIMURA Mamoru	TOBITA Tetsuo
Mountain Hazards	CHIGIRA Masahiro		SAITO Takashi
Slope Conservation	MATSUURA Sumio	TERAJIMA Tomomi	
Research Center on Landslides			
Landslide Dynamics	KAMAI Toshitaka	FUKUOKA Hiroshi	
Landslide Monitoring		SUEMINE Akira	WANG Gonghui
Atmosphere-Hydrosphere Research Group			
Research Division of Atmospheric and Hydrospheric Disasters			
Climate Environment	MUKOUGAWA Hitoshi		IGUCHI Takao
Severe Storm and Atmospheric Environment	ISHIKAWA Hirohiko	TAKEMI Tetsuya	HORIGUCHI Mitsuaki
Wind Engineering and Wind Resistant Structures	KAWAI Hiromasa	MARUYAMA Takashi	ARAKI Tokihiko
Maritime Disasters	MASE Hajime	MORI Nobuhito	YASUDA Tomohiro
Hydrometeorological Disasters	NAKAKITA Eiichi	KIDO Yoshinobu	
Research Center for Fluvial and Coastal Disasters			
Sedimentation Disasters	FUJITA Masaharu	TAKEBAYASHI Hiroshi	
Urban Flood Control	TODA Keiichi	YONEYAMA Nozomu	
River Disaster Prevention System	NAKAGAWA Hajime	KAWAIKE Kenji	BABA Yasuyuki
			ZHANG Hao
Coastal Sedimentary Environment	HIRAISHI Tetsuya		AZUMA Ryokei
Field Research Section for Fluvial and Coastal Hazards		HAYASHI Taiichi	
		MUTO Yasunori	
		TSUTSUMI Daizo	
Water Resources Research Center			
Global Water Dynamics	HORI Tomoharu		NOHARA Daisuke
Regional Water Environment System	KOJIRI Toshiharu	TANAKA Kenji	HAMAGUCHI Toshio
Socio and Eco Environment Risk Management	SUMI Tetsuya	TAKEMON Yasuhiro	
Water Resources Distribution Assessment	*	*	
Hydrologic Environment Systems (sponsored by JWA)	SUZUKI Yasushi	SATO Yoshinobu	MICHIHIRO Yuri

Division of Technical Affairs

Head Professor KAWAI Hiromasa

	Technical Staff
Planning and Information Group	BAN Yasunori, TATSUMI Kenichi, MATSUURA Hideki, SAWADA Masayo, ICHIDA Kotaro
Machine Operations Group	BAN Yasunori, YAMAZAKI Tomoya, KAMO Masato
Machine Development Group	SONODA Yasumi, MIURA Tsutomu, TOMISAKA Kazuhide, YONEDA Itaru, TADA Mitsuhiro
Observation Group	SONODA Yasumi, NISHIMURA Kazuhiro, SONODA Tadaomi, KUBO Teruhiro, KOMATSU Shintaro

History

1951 Establishment of the Disaster Prevention Research Institute (DPRI) as part of Kyoto University for the scientific study of natural disasters, with three departments: (1)Basic Science and Technology Research; (2)Flood Damage Research; and (3)Earthquake Engineering and Wind Resistant Structures.
Establishment of Consultation Committee to replace Establishment Committee for the Institute management.

1953 Establishment of Ujigawa Hydraulics Laboratory.

1958 Establishment of Crustal Movement Section.

1959 Establishment of Landslide Research Section.

1960 Establishment of Hydrology Research Section and Sakurajima Volcano Observatory.

1961 Establishment of Wind Resistant Structure Section and Coastal Disaster Research Section.

1962 Establishment of Geo-Disasters Research Section.
Some sections of the Institute moved to Uji Campus.

1963 Establishment of Geomorphology and Soil Disaster Research Section and Drainage Engineering Research Section (Names of the original three sections were changed to Earthquake Motion Section, Fluvial Disaster Research Section, and Earthquake Resistant Structures Section.)

1964 Establishment of Foundation Seismic Disaster Research Section and Tottori Microearthquake Observatory.

1965 Establishment of Sabo Research Section, Earthquake Prediction and Monitoring Research Section, and Kamitakara Crustal Movement Observatory.

1966 Establishment of Applied Climatology, Shionomisaki Wind Effect Laboratory, and Shirahama Oceanographic Observatory.

1967 Establishment of Dynamics of Foundation Structures Section, Donzurubo Crustal Movement Observatory, and Hodaka Sedimentation Observatory.

1969 Establishment of Tokushima Landslide Observatory and Ogata Wave Observatory.

1970 Establishment of Hokuriku Microearthquake Observatory.
Research Sections and Administration Office were integrated in Uji Campus.

1972 Establishment of Disaster Prevention Science Information Center.

1973 Establishment of Microearthquake Research Section.

1974 Introduction of Working Sections into Administration Office.

1977 Establishment of Miyazaki Crustal Movement Observatory.

1978 Establishment of Severe Storm Research Section.

1979 Establishment of Water Resources Research Center and Termination of Hydrology Research Section Earthquake Resistant Structures Section was renamed as Earthquake Resistant Plastic Structures Section; Establishment of Earthquake Resistant Brittle Structures Section.

1982 Establishment of Flood Control System Research Section.

1986 Establishment of Research Center on Earthquake-resistant system of Urban Infrastructures.

1990 Establishment of Research Center on Earthquake Prediction by the integration of earthquake-prediction related organizations of DPRI and various divisions of the Graduate School of Science of Kyoto University (Crustal Movement Research Section, Earthquake Prediction and Monitoring Section, Microearthquake Research Section, Tottori Microearthquake Observatory, Kamitakara Crustal Movement Observatory, Donzurubo Crustal Movement Observatory, Hokuriku Microearthquake Observatory, and Miyazaki Crustal Movement Observatory).

1992 Termination of Flood Control System Research Section.
Establishment of Research Section for Urban Flood Hazard in Bay Area.

1993 Establishment of Regional Disaster Prevention System Research Center and Termination of Disaster Prevention Science Information Center.

1996 Termination of Research Center on Earthquake-Resistant System of Urban Infrastructures. The Institute was reorganized into five research divisions and five research centers (Integrated Management for Disaster Risk; Earthquake Disaster Prevention; Geohazards; Fluvial and Marine Disasters; Atmospheric Disasters; Research Center for Disaster Environment; Research Center for Earthquake Prediction; Sakurajima Volcano Research Center; Water Resources Research Center; and Research Center for Disaster Reduction Systems). DPRI became a national open institute. Committee for Collaborative Research was established.

1997 Designated as the "Center of Excellence (COE)" of Japan in natural disaster research.

2000 Integration of Uji Campus Administrative Department.

2001 Establishment of Natural Disaster Research Council.

2002 Selected as an institute in the 21st Century COE Program by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).
Change of name from Ujigawa Hydraulics Laboratory to Ujigawa Open Laboratory.

2003 Establishment of Research Center on Landslides.

2004 Establishment of National University Corporation,-Kyoto University.

2005 Establishment of four research groups (Integrated Arts and Sciences for Disaster Reduction; Seismic and Volcanic Hazards Mitigation; Geohazards; and Atmosphere-Hydrosphere Research).

2009 Selection as a Global COE program by MEXT. Establishment of Endowed Research Section for Hydrological Environment System by Japan Weather Association.

2010 Certified as a Joint Usage/Research Center by MEXT. Establishment of Endowed Section for Public Policy Studies on Disaster Reduction by Japan Institute of Construction Engineering.

Ujigawa Hydraulics Laboratory (UHL) in 1953

At present

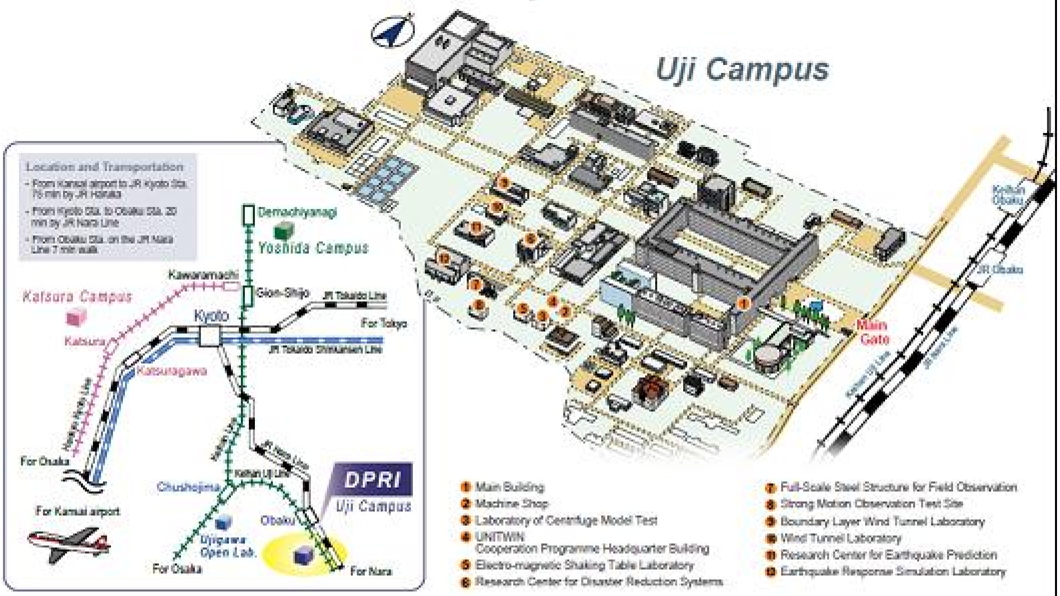
Sakurajima Volcano Research Observatory (SVRO) in 1960

At present

The entrance of DPRI in 1971

At present

Observatories



Statistics

Statistic of DPRI

DPRI Staff	Numbers (as of July 2010)	Students	Numbers (as of July 2010)
Professors	34 (6)	Doctoral Course	64
Associate Professors	31(3)	Master's Course	104
Assistant Professors	27	Undergraduates	34
Research Staffs	19	Research Student	3
TOTAL	111	TOTAL	205

*Remarks (shows the number of overseas visiting professors)

Budget in FY2009

Accounts Recievable (Internal)	Amount (Unit in Thousand Yen)	Accounts Receiveable (External)	Amount (Unit in Thousand Yen)
Management Expenses Grants	630,696	Research Funding Expenses	435,204
Accumulated Reserve for Education and Research	161,396	Donations	118,235
Total Expenses	35,529	Grants-in-aid for Scientific Research	261,234
Facilities Subsidies	112,613	Other Subsidies	157,257
TOTAL	940,234	TOTAL	971,930
Total Accounts (Internal/Exteral)			1,912,164


DPRI-KU
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