東京理科大学「火災安全科学研究拠点」

■研究成果概要報告書

研　究　課　題		A Comparison Study of International Fire Test Method for Façade(ISO 13785-2 Calibration Method)	実 施 年 度 平成 27 年度
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１．研究の背景および目的

現在の建築物は、施工技術の向上と社会の変化等に応じて超高層化や大規模化、複合化されている傾向である。また、このような建築物の中には、デザインの観点に加えて温熱環境と展望などの観点から、外観に要求される機能も多様化している。例えば、温熱環境を考慮して、外観の建築資材である外装材を有機系断熱材を使用した外部断熱工法が採用する事例、開口部の形状が横方向への長大化された事例、開口部の周囲に壁の形状の垂直ルーバーの設置で日射量と視覚的なコントロールなどの事例がある。

火災時の開口部から噴出される熱気流の研究は継続的に行われてきたが、最近の建築物の変化により、火災時の開口噴出熱気流が発生した場合、従来の災害とは異なる危険性が潜在化している可能性が指摘されている。

建築物の延焼は室の内部の区画火災と外壁火災により上層部に拡散する火災性状に区分される。可燃性外壁仕上げ材が設置している建築物の場合、火災発生時に外部の風の影響と外壁仕上げ材の種類などの周辺の条件に沿って垂直に拡散された火炎が建築物の各層の開口部に流入され、区画間の水平方向の火炎が拡散して最終的には建築物全体で火災が拡大される危険性がある。

従って、建築物の外壁火災の安全性を評価する国際試験方法である Façade 試験装置（ISO 13785-2）を用いて実験を行い、TUS と韓国 KICT の実験結果を比較･分析する。

２．利用施設及び利用日

・ Façade Fire Tester(ISO 13785-2)装置　TUS（2016 年 1 月 20 日 ～ 1 月 22 日）

３．実験方法・研究成果、および考察（申請時の計画に対する達成度合いも含む）
※継続課題の場合は，前年度との関係性，進展度合いについても記載すること。

建築物の外壁火災の安全性を評価する国際試験方法である Façade 試験装置（ISO 13785-2）の概要を図 1 に示す。

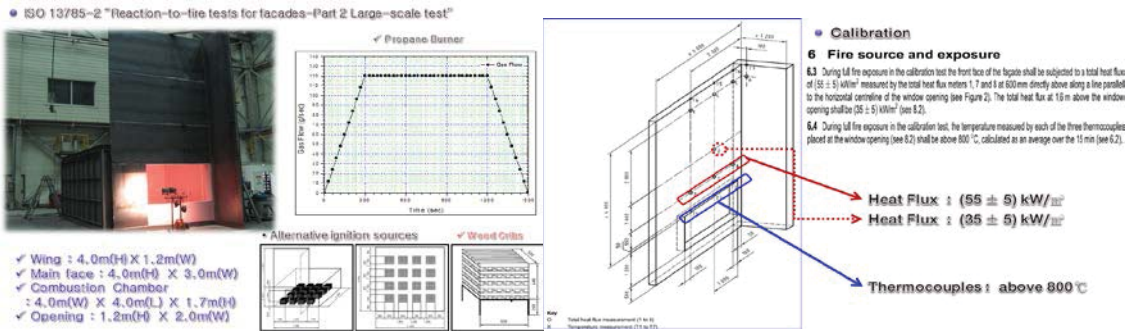
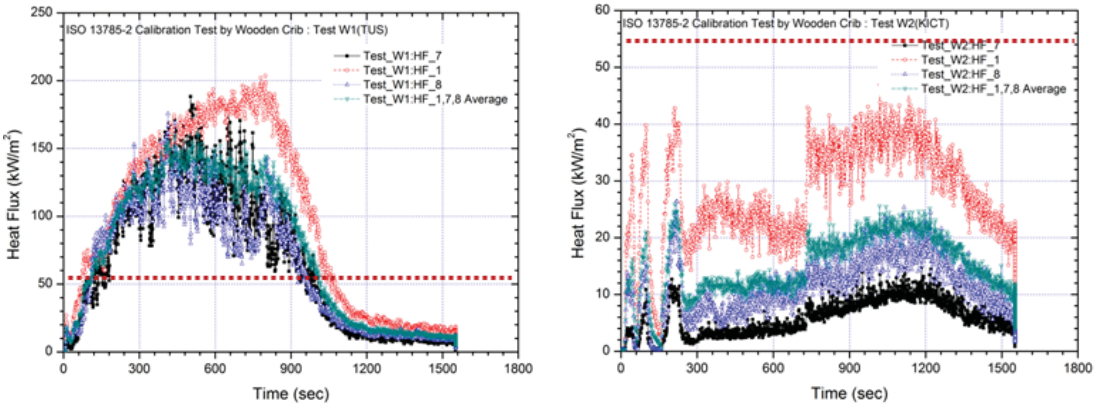


図1　Façade Test(ISO 13785-2) & Calibration Method

2015 年度の研究計画は以下の通りである。

1. Conduct the cone calorimeter test(ISO 5660) with wooden cribs
2. Numerical Simulation of Façade calibration model
3. Analysis of calibration results(Simulation vs. Real Scale Test)
4. To Clarify to Alternative Ignition Source of the Façade test method(ISO 13785-2)
5. Correlation analysis Study on input airflow and ventilation condition(FDS Simulation)
6. Summary of research results and Revision ISO 13785-2 Calibration Methods

－　ISO 13785-2 の試験規格では火源として LPG, Wooden cribs，Heptane, Acetone が使用できる。しかし、Wooden cribs の木の種類や Heptane, Acetone の火源容器の大きさ等が具体的に決まってない状態である。その中で 2014 年度 TUS および KICT で行った Wooden cribs の比較実験では以下のように TUS の方が KICT より約 5 倍になる結果が得られた。



a) Test W1（TUS）　　b) Test W2（KICT）

図２　Wooden cribs を用いた TUS および KICT の比較実験の熱流束結果

そして、2015 年度には TUS と KICT の各実験で使用した Wooden cribs を用い Cone calorimeter test(ISO 5660)を 3 回ずつ行い、2 つの木材の単位面積当たり総発熱速度を比較した。その結果、TUS で使った木材の方が KICT より 単位面積当たり総発熱速度が約 1.5 倍高い結果を示した。この結果により ISO 13785-2 の試験規格の中で Wooden cribs について具体的な木材の情報の提示が必要と判断する。

Table 1 Wooden cribs の Cone calorimeter test 結果

	TUS			KICT		
	J-1	J-2	J-3	K-1	K-2	K-3
	[MJ/㎡]					
Total heat release per unit area	59.1	53.0	63.0	44.1	46.3	42.4

－ TUS と KICT の実験結果を基に FDS ver5 を用い、Façade の温度および熱流束の検討のための解析を行った。その概要と解析結果を図 3～8 に示す。

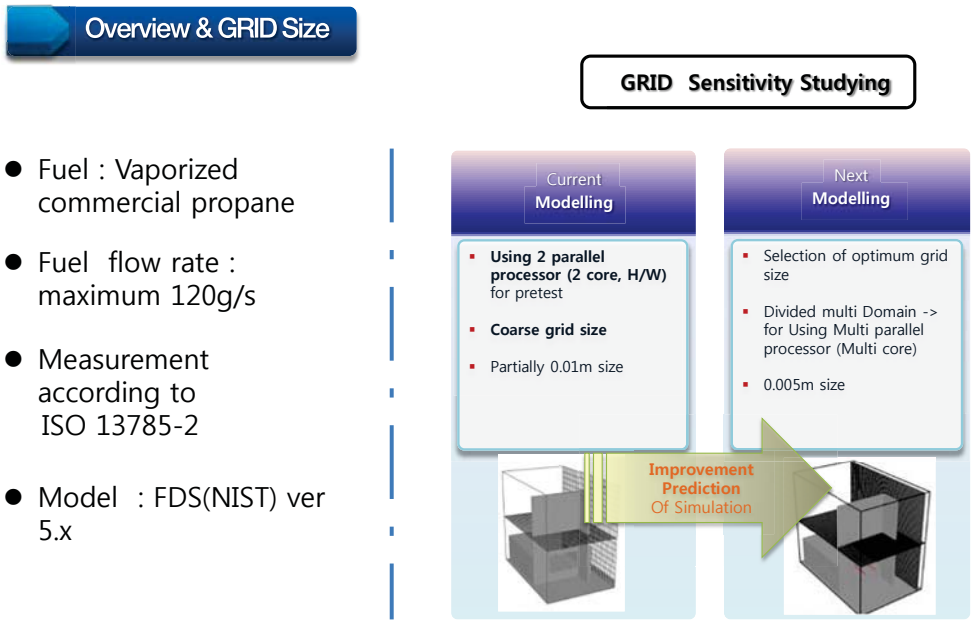


図 3 FDS の解析概要

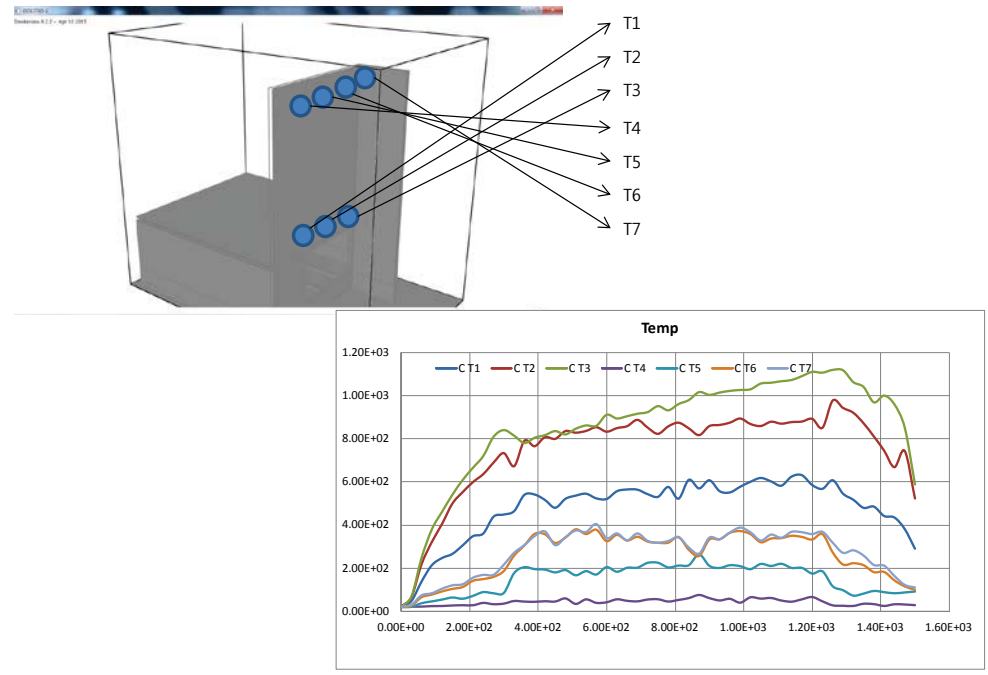


図 4　解析の温度結果

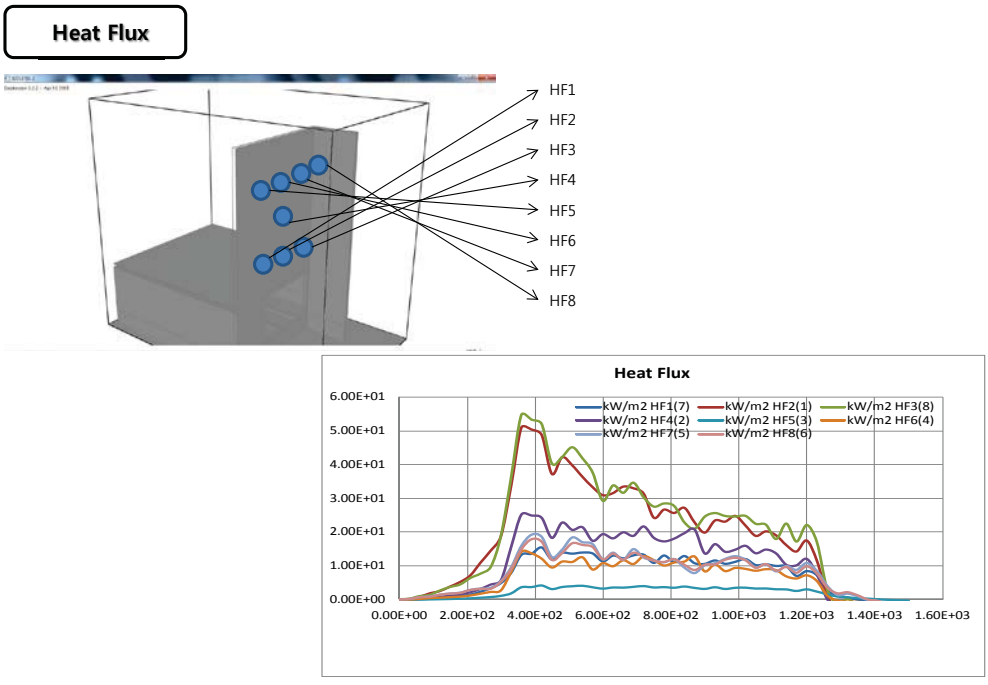


図 5　　解析の熱流束結果

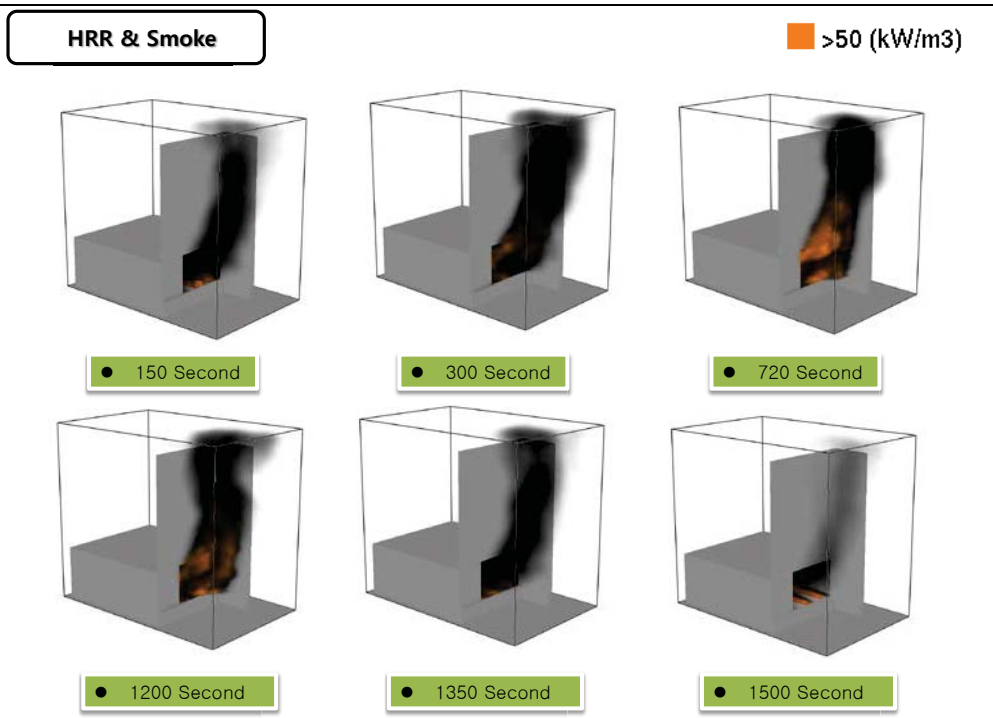


図 6　解析の様相

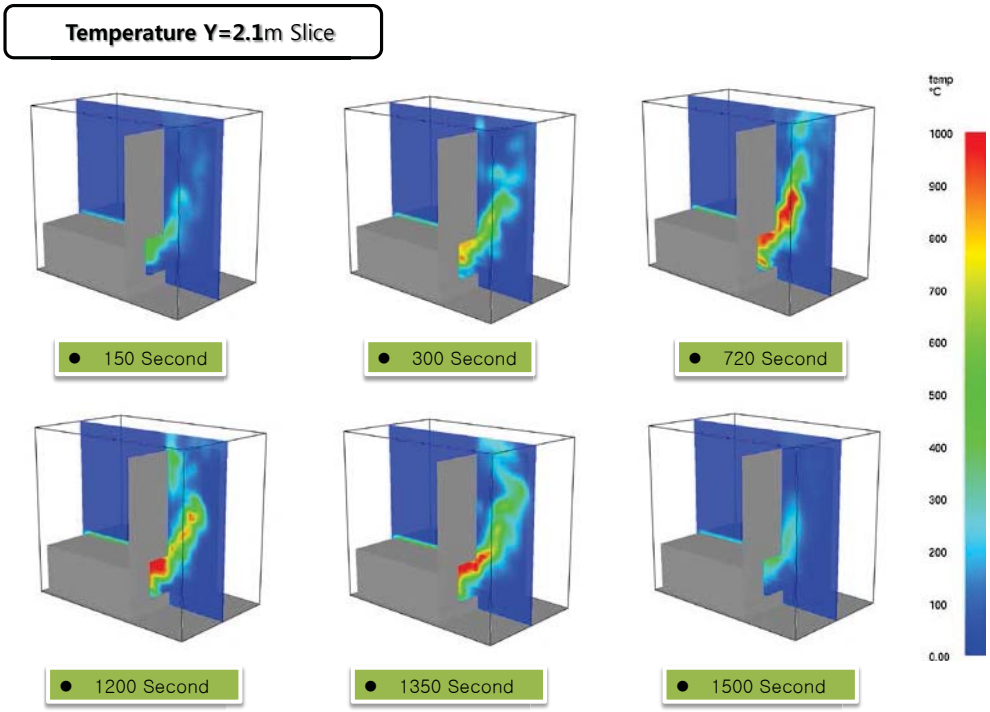


図 7　解析の温度結果

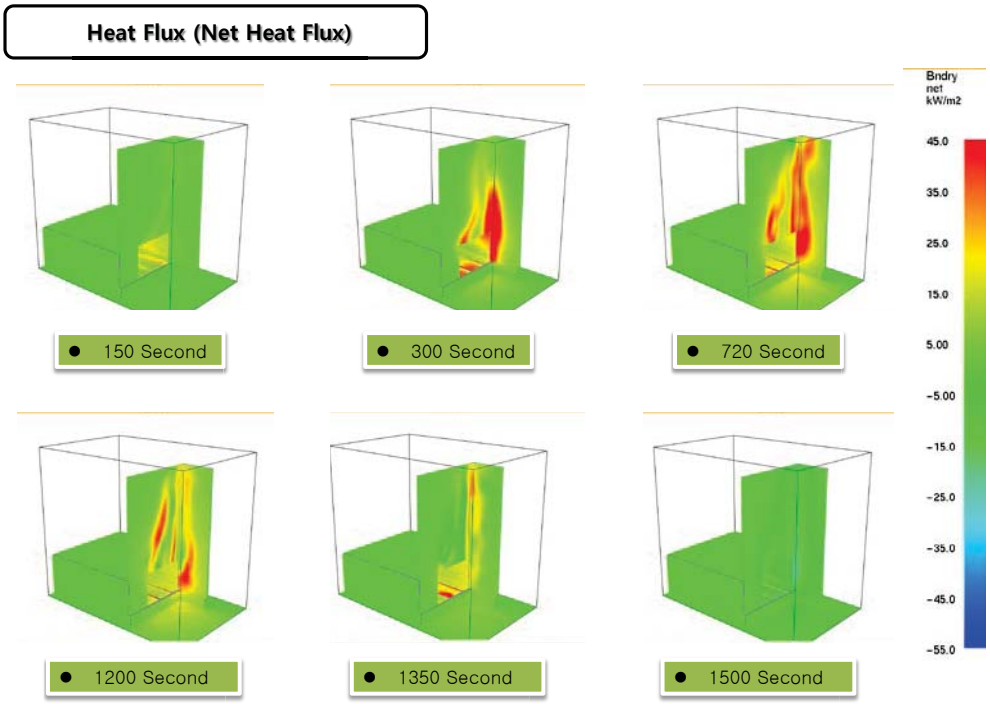


図 8　解析の熱流束結果

－　ISO 13785-2 の試験規格に提案されている Alternative Ignition Source（Heptane, Acetone）に関して実験を行い、Alternative Ignition Source としての実効性について検討する。

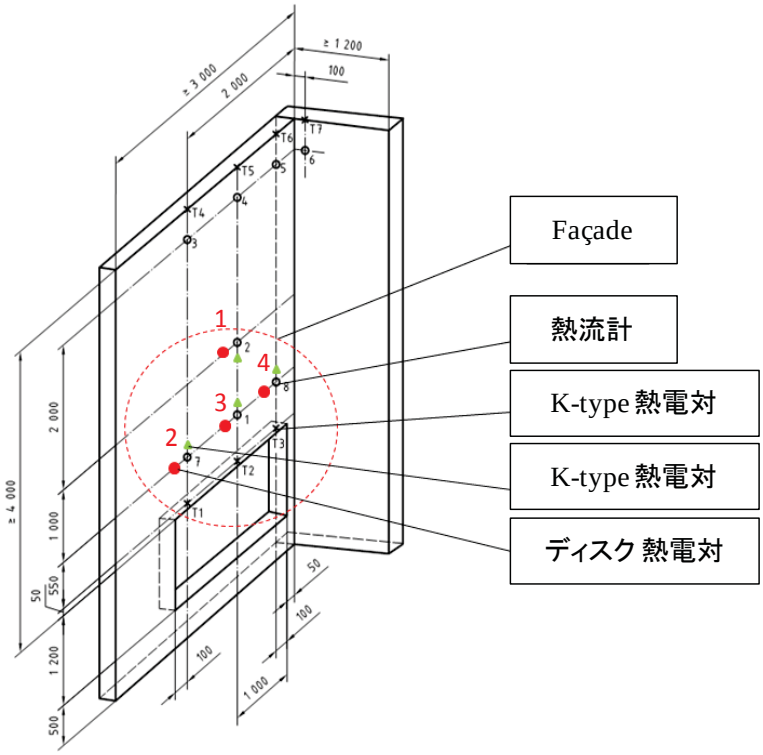
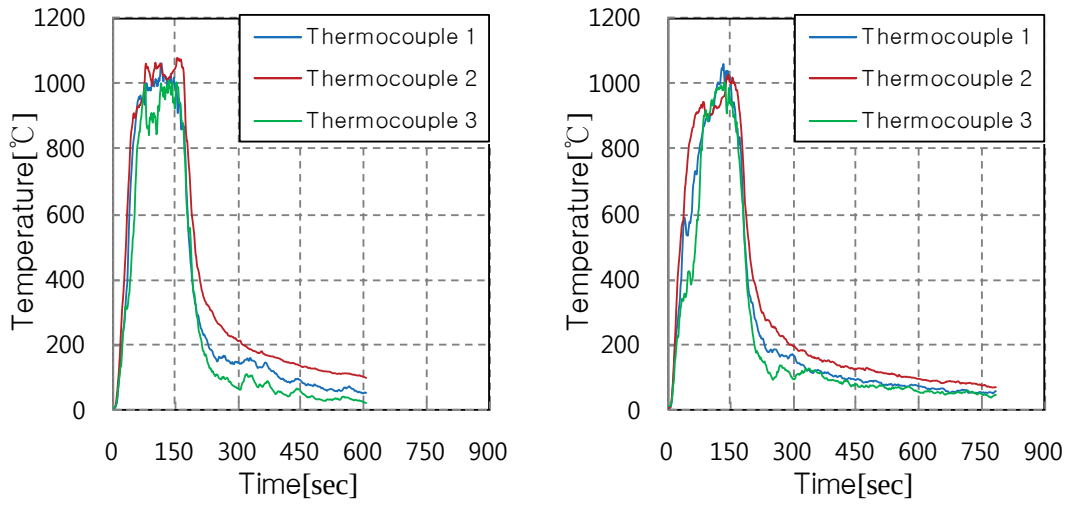


図 9　実験の測定項目

ISO の規格では Alternative Ignition Source として Heptane と Acetone を火源容器の大きさに関わらず単純に量(60L)のみ規定している。そこで、 Heptane と Acetone を同様な大きさの容器に 60L ずつ入り実験を行った。実験の測定項目を図 9 に示す。

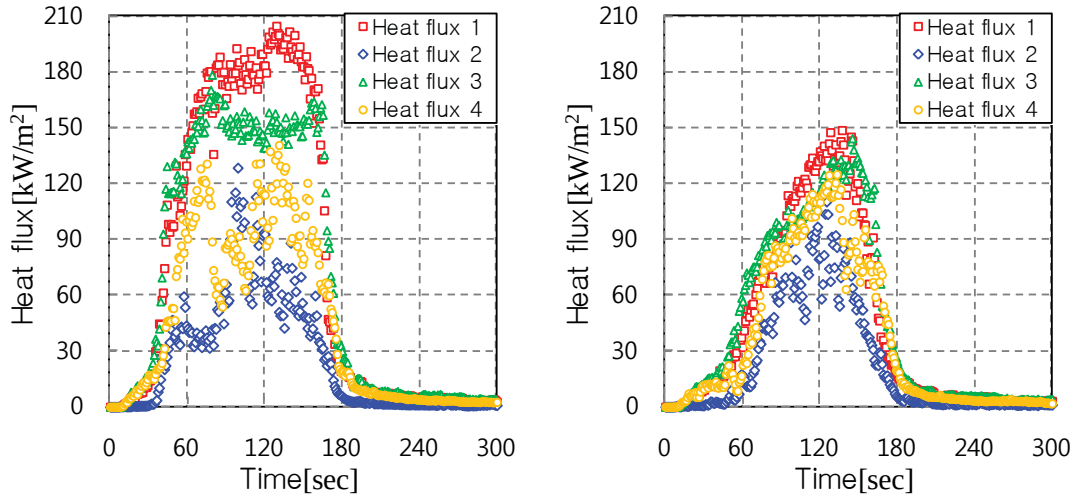
実験結果、図 10 のように Heptane と Acetone の開口部上端の温度は概ね一致した。しかし、 図 11 の熱流束結果を見ると大きい差が見られた。これは Acetone より Heptane の方が未燃焼ガスの影響が大きいためだと考えられる。

結果により ISO 13785-2 の試験規格の中で Alternative Ignition Source として Heptane と Acetone について具体的な 情報の提示が必要と判断する。



a) Heptane　　b) Acetone

図 10　開口部上端の温度測定結果



a) Heptane　　b) Acetone

図 11　Façade の熱流束測定結果

－ 2014～2015 年度の研究結果を基に現在の ISO 13785-2 の問題点を ISO TC92 で報告し、以下の改定案を提案した。

ISO 13785-2 revision: Project proposal

Executive summary

ISO 13785-2 was developed in ISO TC92 as a combination of large-scale facade tests available in 1990´s and experience available at that time. Since then, significant experience has been gathered using the method as well as similar test methods worldwide. The need for revising ISO 13785-2 is obvious, and in particular concerns the following elements:

- Fire load and its calibration: 3 types of fire load allowed need to be equalized;
- Heat flux measurement: plate thermometer can successfully replace heat-flux meters;
- Testing structural details of the tested facade system.

Representing a different fire scenario than reaction to fire or fire resistance, this type of test is needed globally, and covers a wide range of applications: Exterior Insulation Finish Systems (EIFS or ETICS), metal composite material cladding, high laminates, Structural Insulation Panel Systems (SIPS) / insulated sandwich panel systems, Rain Screen Cladding (RSC) or ventilated facades, weather and combustible wall cavity insulation, external timber panelling and facades, prefabricated facade elements, smart facade components, green facades etc.

To serve the current and future needs, attention could also be given to the following areas in the standard:

- Measurements and observations, including new items like falling parts and continuous smouldering;
- Presentation of test results so that they are compatible with most used regulatory requirements;
- Use of the method for Fire Safety Engineering so that SC4 can give their input into the test method;
- Relation of the method with the intermediate-scale screening method ISO 13785-1 which can be used as an approval test for specific areas of use.

ISO 13785-2 test facilities exist in Korea, Japan, Czech Republic, Poland. ISO 13785-1 and/or -2 are referred to in regulations of Czech republic and Korea, and have been used on voluntary basis in Poland and Slovakia; Australia and China are considering using the standard.

Background

This document has been prepared after an informal meeting of experts having certain experience with ISO 13785 series: Kye-Won Park (KR); Lars Bostrom (S); Miroslav Smolka, Stefan Rastocky (SK); Andrzej Kolbrecki (PL); Jaroslav Dufek (CZ).

During the meeting in August 2015, calibration test has been performed using wood crib as the fire load, and plate thermometers as the alternative instrument for measuring heat flux. The results are currently used for modelling.

The initial proposal to revise ISO 13785-2 presented by Kye-Won Park, the volunteer potential project leader, identified areas for improvement and proposals that were agreed and supplemented by the other experts. The experience from and expertise needed for ISO 13785-2 revision relates to other large-scale facade fire spread tests, e.g. BS 8414, SP105, LEPIR II, tests used in North America, etc., which use the same principle of testing and test specimen configuration as ISO 13785-2.

Request to ISO TC92 SC1

ISO TC92 SC1 is requested to initiate a CIB ballot to revise ISO 13785-2 and use this document for information for the decision to be made by ISO members, and as the initial basis for the revision.

see the Annex to this document for details.

Annex: Areas to be addressed during ISO 13785-2 revision

Similar to other large-scale fire tests e.g. fire resistance, the purpose of ISO 13785-2 should be to provide an equal level for product evaluation and data for classification, not a simulation of reality.

Fire load

The standard currently allows using three types of fire load:

- Propane burners
- Wood crib
- Heptane

Although claimed to be identical, it has been found that these fire sources are not equal. Data have been provided to ISO TC92 SC1 from experiments carried out in Korea and Japan. Additional information is available from PL and CZ on wood crib and liquid fuels. The following parameters need to be addressed:

- Dimensions of combustion chamber.
- Definition of possible fire sources – there are two options:
    - define one source as the standard one, e.g. gas burners; and allow using wood crib and heptane as alternatives, based on strict calibration criteria rather than specifying details of the fire load.
    - define the sole fire source, preferably gas burners, and its detailed specification without its calibration (note: ISO 13785-1 allows propane burner only).
- Using heat flux, or temperatures, or both, for calibrating the fire source(s).
- If heptane is agreed to remain part of the standard, its amount need to be re-defined based on experience from ITB and KICT. 100 litres was found appropriate, not 60 litres as currently defined in the standard; and we will have to deal with differing evaporation rate over time which depends on the vessel size and shape.
- Smoke radiation properties; these have not been found problematic by SP as long as calibration criteria are met.
- Air supply to gas burners and to the combustion chamber.
- Ignition of wood crib in 1 minute (it was found possible by PAVUS – the procedure can be described in the standard).
- Ventilation in the test room (max 1 m/s is suggested), exhaust hood position (if used).
- Positioning the fire source relative to the front plane of the specimen instead of the back wall position.

Some of the issues are just a matter of decision, some can be decided based on available experience from ISO 13785-2 or similar test methods (see the References).

Heat Flux

ISO 13785-2 uses heat flux measurements and rightly so, as heat influx is the most

relevant parameter for facades. It uses Schmidt-Boelter type heat flux meters which often get damaged during tests especially when testing facades with combustible elements. The use of these should be removed from the standard, or they can be allowed as alternative for calibration.

Plate thermometer (PT) is a robust & simple device capable of measuring heat flux and temperature. When used in conjunction with a conventional thermocouple measuring gas-phase temperature, it can be used to measure incident heat flux with sufficient precision for the purpose of large-scale fire testing. Theory and experience using PT in large-scale fire testing are plentiful. It has been proven to measure heat influx on the specimen surface so that other influences can be eliminated.

As the PT gives data as temperatures, the measured values and calibration criteria should be given as temperature readings from PTs; calculation of incident heat flux should make part of an Annex to ISO 13785-2, e.g. for calibrating alternative fire sources.

To evaluate the fire attack on the specimen, PTs should be used „looking" into the combustion chamber and at the lintel; in addition, a few PTs should measure incident heat flux on the specimen surface at different heights.

Test specimen

The test is intended to evaluate all types of facades. The size and configuration of the specimen corresponds to other major facade tests and there is no need to change it. The presence of the lateral wing provides better repeatability and is closer to worst-case situation (although not necessarily the worst possible design).

It will be useful to make it clear in the Scope that the test is intended to evaluate the phenomenon of facade spread, regardless if the tested specimen is a cladding attached to a non-combustible wall, or a segment of a wall containing combustible elements.

As certain large-scale facade tests use a dummy or real window, it might become an optional part of the test specimen.

It should be made clear that the specimen should contain real structural details, e.g. lintel. The value of the test is to evaluate real configurations used in practice. It can obviously be used to design such structural details. ISO 13785-1 might serve as the source of additional information to evaluate alternative structural details without the need to undergo the ISO 13785-2 large-scale test for every variation in the specimen design at the lintel or the facade system base.

Measured values and presentation of results

The list of measured values and observations need to be based on existing requirements in countries using a large-scale facade test as well as needs of performance-based

approach to avoid the risk of fire spread on exterior wall surface or through its components and cavities.

What is obvioulsy missing is:

- list of observations like falling parts and burning droplets, an dtheir evaluation.
- continuous smouldering combustion (which can be evaluated by visual observation during the test or measuring temperatures close to the lintel inside the structure for a period of time after the test).
- Temperature measurements in mid-thickness of significant layers and cavities.

Test results should be presented as quantitative values and indicators; qualitative observations are useful but they should be used as additional information.

Use of standard for Fire Safety Engineering

Facade fire spread is possible to model as test method or real building contidions. Owing to on-going activities in ISO TC92 SC4+SC1 and ISO TC 92 SC1 WG11 (Use of reaction to fire tests for FSE), ISO 13785-2 has the potential to become a model case for the development of a test method to provide data that can be modelled and serve the purpose of performance-based building design.

４．今後の展望（今後の発展性，見込み等についても記述）

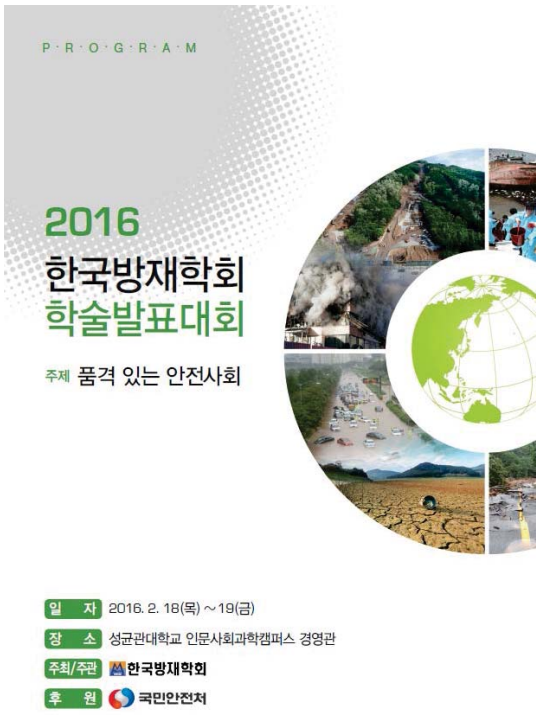
2 年間の研究結果を基に、ISO 13785-2 試験規格の火源条件に対する問題点を確認した。今後の世界の複数の国らとともに問題の解決のためよい参考資料として活用可能と判断される。また、火源に対する具体的な追加検証実験や分析を通じて試験方法を改正し、建築物の外装材を評価するための信頼度の高い規格の確立ができると期待される。

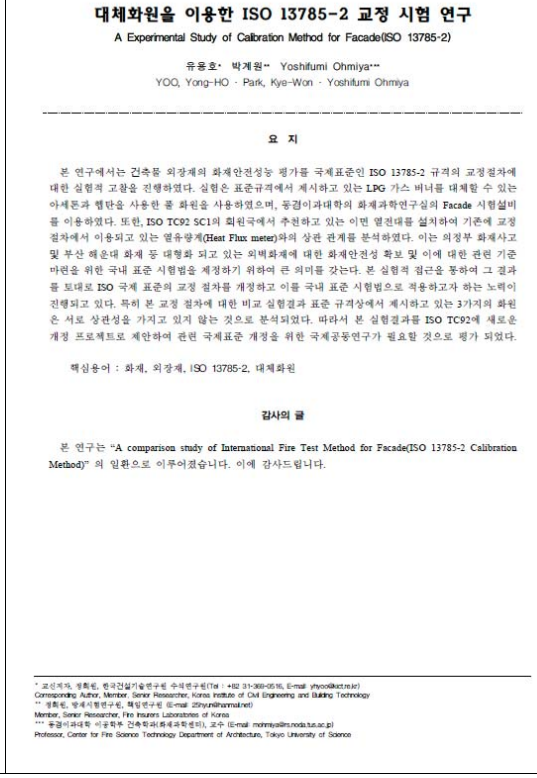
５．成果の公表状況（学会への発表，学術誌への投稿等を記述。予定も含む）

□ “A Experimental Study of Collaboration Method for Façade(ISO 13785-2)”, Feb. 18th, 2016, , 2016 年度の韓国防災学会春季学術大会の論文集

□ “An International Collaborative Experimental Research for the Façade Fire Test Standard(ISO 13785-2) Revision”, Apr. 28th, 2016 , 2016 年度の韓国火災消防学会春季学術大会の論文集

□ ISO TC92 SC1 meeting in Linz (April. 11th ~ 15th, 2016)





대체화원을 이용한 ISO 13785-2 교정 시험 연구

A Experimental Study of Calibration Method for Facade(ISO 13785-2)

유용호* 박계원** Yoshifumi Ohmiya***

YOO, Yong-HO · Park, Kye-Won · Yoshifumi Ohmiya

요 지

본 연구에서는 건축물 외장재의 화재안전성능 평가를 국제표준인 ISO 13785-2 규격의 교정절차에 대한 실험적 고찰을 진행하였다. 실험은 표준규격에서 제시하고 있는 LPG 가스 버너를 대체할 수 있는 아세톤과 혼합을 사용한 폼 화원을 사용하였으며, 동경이과대학의 화재과학연구실의 Facade 시험설비를 이용하였다. 또한, ISO TC92 SC1의 회원국에서 추천하고 있는 이면 열전대를 설치하여 기존에 교정절차에서 이용되고 있는 열유량계(Heat Flux meter)와의 상관 관계를 분석하였다. 이는 의정부 화재사고 및 부산 해운대 화재 등 대형화 되고 있는 외벽화재에 대한 화재안전성 확보 및 이에 대한 관련 기준 마련을 위한 국내 표준 시험법을 제정하기 위하여 큰 의미를 갖는다. 본 실험적 접근을 통하여 그 결과를 토대로 ISO 국제 표준의 교정 절차를 개정하고 이를 국내 표준 시험법으로 적용하고자 하는 노력이 진행되고 있다. 특히 본 교정 절차에 대한 비교 실험결과 표준 규격상에서 제시하고 있는 3가지의 화원은 서로 상관성을 가지고 있지 않는 것으로 분석되었다. 따라서 본 실험결과를 ISO TC92에 새로운 개정 프로젝트로 제안하여 관련 국제표준 개정을 위한 국제공동연구가 필요할 것으로 평가 되었다.

핵심용어 : 화재, 외장재, ISO 13785-2, 대체화원

감사의 글

본 연구는 "A comparison study of International Fire Test Method for Facade(ISO 13785-2 Calibration Method)" 의 일환으로 이루어졌습니다. 이에 감사드립니다.

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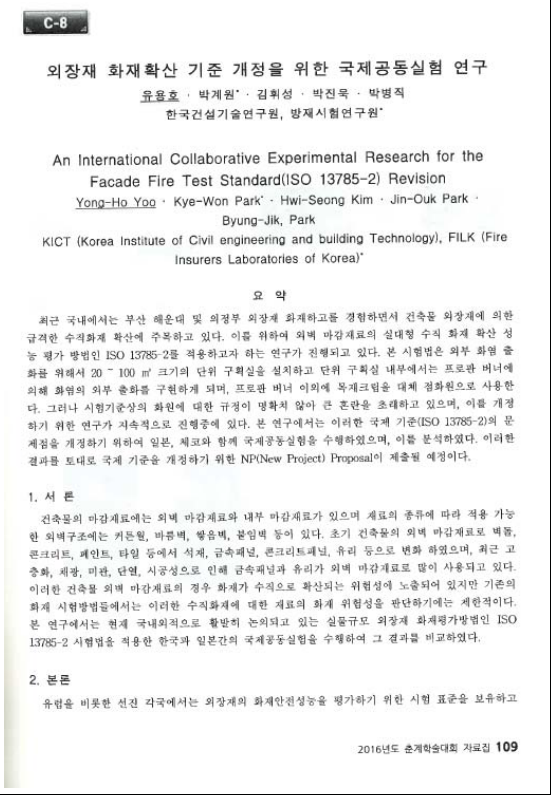

C-8

외장재 화재확산 기준 개정을 위한 국제공동실험 연구

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An International Collaborative Experimental Research for the Facade Fire Test Standard(ISO 13785-2) Revision

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요 약

최근 국내에서는 부산 해운대 및 의정부 외장재 화재하고를 경험하면서 건축물 외장재에 의한 급격한 수직화재 확산에 주목하고 있다. 이를 위하여 외벽 마감재료의 실대형 수직 화재 확산 성능 평가 방법인 ISO 13785-2를 적용하고자 하는 연구가 진행되고 있다. 본 시험법은 외부 화염 출화를 위해서 20 ~ 100 ㎡ 크기의 단위 구획실을 설치하고 단위 구획실 내부에서는 프로판 버너에 의해 화염의 외부 출화를 구현하게 되며, 프로판 버너 이외에 목재크립을 대체 점화원으로 사용한다. 그러나 시험기준상의 화원에 대한 규정이 명확치 않아 큰 혼란을 초래하고 있으며, 이를 개정하기 위한 연구가 지속적으로 진행중에 있다. 본 연구에서는 이러한 국제 기준(ISO 13785-2)의 문제점을 개정하기 위하여 일본, 체코와 함께 국제공동실험을 수행하였으며, 이를 분석하였다. 이러한 결과를 토대로 국제 기준을 개정하기 위한 NP(New Project) Proposal이 제출될 예정이다.

1. 서 론

건축물의 마감재료에는 외벽 마감재료와 내부 마감재료가 있으며 재료의 종류에 따라 적용 가능한 외벽구조에는 커튼월, 바름벽, 방음벽, 붙임벽 등이 있다. 초기 건축물의 외벽 마감재료로 벽돌, 콘크리트, 페인트, 타일 등에서 석재, 금속패널, 콘크리트패널, 유리 등으로 변화 하였으며, 최근 고층화, 세장, 미관, 단열, 시공성으로 인해 금속패널과 유리가 외벽 마감재료로 많이 사용되고 있다. 이러한 건축물 외벽 마감재료의 경우 화재가 수직으로 확산되는 위험성에 노출되어 있지만 기존의 화재 시험방법들에서는 이러한 수직화재에 대한 재료의 화재 위험성을 판단하기에는 제한적이다. 본 연구에서는 현재 국내외적으로 활발히 논의되고 있는 실물규모 외장재 화재평가방법인 ISO 13785-2 시험법을 적용한 한국과 일본간의 국제공동실험을 수행하여 그 결과를 비교하였다.

2. 본론

유럽을 비롯한 선진 각국에서는 외장재의 화재안전성능을 평가하기 위한 시험 표준을 보유하고

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