a. Load-bearing exterior walls shall also comply with the fire-resistance rating requirements of Table 601.
b. For special requirements for Group U occupancies see Section 406.1.2
c. See Section 705.1.1 for party walls.
d. Open parking garages complying with Section 406 shall not be required to have a fire-resistance rating.
e. The fire-resistance rating of an exterior wall is determined based upon the fire separation distance of the exterior wall and the story in which the wall is located.
f. In buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1, nonbearing exterior walls shall not be required to have a fire-resistance rating.
g. Exterior walls in the first story that are facing a street and have a fire separation distance of greater than 15 feet (4572 mm), or facing an unoccupied space shall not be required to have a fire-resistance rating. The unoccupied space shall be on the same lot or dedicated for public use, shall not be less than 30 feet (9144 mm) in width, and shall have access from a street by a posted fire lane in accordance with the *International Fire Code*.

Reason: Table 602 contains the fire-resistance ratings for exterior walls, both load-bearing and nonload-bearing walls, based upon the type of construction and occupancy classification of the building, and the fire separation distance of the exterior wall in question.

Once the user establishes the fire-resistance rating for each exterior wall, they are directed to Section 704.8 for the allowable amount of openings in that exterior wall. In Table 704.8, the allowable amounts of openings in exterior walls is only dependent upon the type of opening (unprotected vs. protected) and the fire separation distance of the exterior wall in question, type of construction and occupancy classification have nothing to do with the amount openings allowed.

This proposal seeks to do 2 things:

- Expand the fire separation distances in Table 602 to more closely match those found in Table 704.8.
- Add 2 footnotes that correlate to the provisions found in Sections 704.8.1 and 704.8.2 for exceptions to the amounts of openings allowed in exterior walls.

Text of Section 704.8.1 and 704.8.2 provided for information purposes:

704.8.1 Automatic sprinkler system. In buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1, the maximum allowable area of unprotected openings in occupancies other than Groups H-1, H-2 and H-3 shall be the same as the tabulated limitations for protected openings.

704.8.2 First story. In occupancies other than Group H, unlimited unprotected openings are permitted in the first story of exterior walls facing a street that have a fire separation distance of greater than 15 feet (4572 mm), or facing an unoccupied space. The unoccupied space shall be on the same lot or dedicated for public use, shall not be less than 30 feet (9144 mm) in width, and shall have access from a street by a posted fire lane in accordance with the International Fire Code.

Cost Impact: The code change proposal will not increase the cost of construction.

Public Hearing:	Committee:	AS	AM	D
	Assembly:	ASF	AMF	DF

G164–06/07
602.1

Proponent: Susan Lamont, Arup Fire, San Francisco, CA

Revise as follows:

602.1 General. Buildings and structures erected or to be erected, altered or extended in height or area shall be classified in one of the five construction types defined in Sections 602.2 through 602.5. The building elements acting as single members shall have a fire-resistance rating not less than that specified in Table 601 and exterior walls shall have a fire-resistance rating not less than that specified in Table 602. Alternatively and where approved by the local authority the structural frame acting as a whole or part assembly shall be shown by global structural analysis to have a fire resistance rating that meets the intent of the life safety requirements of this code which may be equivalent to or greater than that that specified in Table 601.

When a whole or part assembly is assessed in a global structural analysis for the fire situation, a series of credible worst case fires, the relevant heat transfer calculations, the relevant failure modes during fire exposure, the relevant loads, the temperature-dependent material properties and member stiffness as well as the effects of thermal expansions shall be taken into account. The impact of structural deformations on compartmentation shall also be considered by the design. The calculations should be carried out using the standard time-temperature curve or an agreed set of design basis fires as appropriate taking into account credible fire load, compartment dimensions, properties of wall linings and the percentage of unprotected openings.

Reason: The purpose of the code change is to include new text such that performance based design of structural steel frames can be proposed on projects. This means that the IBC would allow performance based design for fire resistance similarly to other international codes for example in the UK, Europe and Australia. Also to recognize that the performance of structural members in a real fire can be very different to the fire resistance of single members i.e. a beam, column or slab acting in isolation of the rest of the frame in a standard furnace.

This is important because savings in structural fire protection can be made when structures are robustly designed but also weaknesses in the structural frame which can exist when thermal expansion forces act on a structure during a fire can be identified and designed against. This is particularly important in innovative structural design and iconic buildings which are generally much taller or have longer spans and cannot be adequately tested in standard furnace tests. The methodology however is applicable to any structure.

The recommendations in the IBC for fire resistance are based on single element tests in a standard furnace. Although this approach is an essential requirement of the regulatory system and enables engineers, manufacturers and building officials to compare the relative performance of different structural components and materials for a range of fire resistance periods it does not represent the real response of structures in real fires. The fire is not necessarily representative of many credible worst case fires and the forces induced in single elements in a furnace can be very different to those induced as a result of restrained thermal expansion and alternative load paths in a highly redundant frame.

As the understanding of the science of fire develops, and its resulting effect on materials and structure, more advanced validated tools are becoming available for engineers for use in the design process.

It is becoming increasingly clear through research and performance based design projects that designing structures with the single aim of protecting structural materials to meet the code requirements for hourly fire resistance, may result in intrinsic weaknesses within the structural stability system. Alternatively it can mean ignoring intrinsic strengths. Passive fire protection simply delays the heating of steel members it does not eliminate it thus protected steel members still get hot and expand. This expansion allows floors to reach high deflections which can be beneficial because alternative load paths exist such as catenary action in beams or tensile membrane action in slabs. However expansion also generates forces and moments which the primary structure, particularly the columns have to resist and were never designed or tested to resist.

The sole aim of structural fire engineering proposed in the code change is to quantify the response of the proposed “cold temperature” structural design, in realistic fire scenarios, in order to determine if this response is acceptable. Strengths and weaknesses can then be clearly identified and addressed within the design, as appropriate.

In the investigation of the WTC collapse NIST set out a series of recommendations to be considered in code development. One of these (recommendation 9) specifically addresses the need to calculate structural fire response in design of tall or innovative buildings.

Research into the fire response of structures has been developing for many years ever since the first standard furnace test over 100 years ago. The understanding of the whole frame response to fire has however increased rapidly in the last 15 years with the Broadgate Fire (a multi- storey composite steel frame caught fire at night during construction when most of the steel frame was unprotected and remained standing after a severe post-flashover fire) in the UK, the detailed analysis of the Cardington 8-storey composite steel frame fire tests in the UK and Europe, similar tests and research in New Zealand and Australia, and onwards to the analysis of the WTC collapse on 9-11 by NIST and others, and currently the recent Torre Windsor fire in Madrid, Spain.

The Cardington Frame tests enabled engineers to measure temperatures and deflections in a whole series of compartment fire tests where the steel beams were left unprotected on a real composite steel frame and temperatures in the compartment exceeded 1000C for up to an hour. The tests and subsequent modeling of the tests showed that alternative load carrying mechanisms develop in fire when the composite slab and beams deflect as a result of thermal expansion and thermal bowing. These mechanisms allow the gravity and live loads to be supported in catenary action in the beams and tensile membrane action in the slab. For the 9m span beams which formed the Cardington Frame failure of the structure was not observed even in the largest post-flashover compartment fires.

Recent research is now considering longer spans (up to 21m) and different steel members such as trusses or deep beams with many penetrations in the web which typically heat more quickly than hot-rolled beam sections. As at Cardington there are alternative load paths but the much larger deflections as a consequence of the longer spans, need to be addressed and sometimes simply protecting the member in accordance with prescriptive rules is not necessarily the best solution.

Arup Fire already use finite element analysis techniques validated for fire by the Cardington Large Building Test Frame program, and more recently used to quantify the WTC collapse sequence, in design.

The references and standards listed in the Bibliography below outlines the background and the basis of the performance based design methodology proposed, the reasons why it is important for design and appropriate validation for software.

The contents of the references can be summarized as follows;

A four step approach is required for a global structural fire analysis as follows:

a. determine reasonable design basis fire scenarios
b. quantify the heat transfer from these fires to representative structural elements
c. quantify the mechanical response of the elements for the entire duration of the fire
d. determine appropriate passive fire protection and/or structural detailing based on this response

The fire size is the main input to a structural fire analysis. The Design Fires proposed should address (a) the quantity of fuel available (b) the quantity of ventilation through the glazed façade, c) compartment dimensions and d) properties of the wall linings.

Heat transfer analyses provide the temperature variation with time along the length and through each section of all structural materials during the fire exposure. It is from this data using a fully validated non-linear finite element analysis package that the mechanical response of the structure to the fire can be quantified.

The software used for heat transfer and structural analysis needs to be validated against full scale test data for example the Cardington frame fire tests.

The design approach is important to calculate the structural response of buildings to fire because current prescriptive rules ignore the forces generated in building elements by thermal expansion therefore design teams can either over design members or ignore inherent weaknesses. Many of the innovative structures developed by design teams with long spans for example cannot be adequately tested in a standard furnace.

This approach is described in British Standards, Eurocodes and design guides in Australia, New Zealand and around the world. It is most widely used in the UK and Europe because the fundamental research was conducted there but the methodology can be applied to performance based design in any country.

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The Steel Construction Institute. Structural fire engineering, "Investigation of Broadgate Phase 8 Fire", technical report June 1991.
The University of Edinburgh, Final report of the DETR-PIT project: Behaviour of steel framed structures under fire conditions. Technical report, 2000. www.civ.ed.ac.uk/research/fire/project/main.html.
Usmani A.S. Chung Y.C. and Torero J.L., How Did the WTC Collapse: A New Theory Fire Safety Journal, 38, 6, 501-591, 2003.
Usmani A.S., Rotter J.M. , Lamont S., A.M.Sanad, Gillie M.. Fundamental principles of structural behaviour under thermal effects Fire Safety Journal, 36, 721-744, 2001.

Cost Impact: The code change proposal will not increase the cost of construction unless the structural design is such that it is particularly susceptible to fire in which case changes to the design may be necessary. In most cases these changes can be offset by savings in passive fire protection to secondary members which have been shown by the performance based analysis to be redundant.

Analysis: There are related code changes submitted by this proponent to the IBC FS committee.

Public Hearing:	Committee:	AS	AM	D
	Assembly:	ASF	AMF	DF

G165–06/07

602.5.1 (New), 202

Proponent: Mike Moore, Newport Partners, representing Dietrich Metal Framing

1. Add new text as follows:

602.5.1 Structural framing. All structural framing shall be of termite-resistant material in areas subject to Formosan termites as determined by the local building official.

2. Add new definition as follows:

SECTION 202
DEFINITIONS

TERMITE RESISTANT MATERIAL Pressure preservatively treated wood, naturally durable termite resistant wood as defined in Section 2302.1, steel, concrete, masonry, or other approved material.

Reason: This code change is intended to strengthen current termite protection requirements within the code to provide sufficient protection in areas subject to the Formosan subterranean termite (FST). The change would require protection of a home's structural members in areas subject to the (FST) – an invasive species that causes $1 billion[1] in damage and control measures annually. Hawaiian building code currently requires this protection for its structures, where the FST is responsible for $100 million in annual control measures and damages. Louisiana, where the FST has the largest foothold in the contiguous states, is now subject to $500 million in annual control measures and damages.

Repeated research has demonstrated that termiticides alone can be insufficient in protecting a structure from FSTs. Termiticides degrade over time and can be voided by landscaping, leaching into soil, heavy rains, or lapses between treatments. According to the USDA, "the Formosan termite has demonstrated the ability to infest wooden structures even though the soil surrounding them has been treated."[2] A change to current code requirements is therefore necessary to adequately protect a building's structure from the FST. Specifying that all structural members be termite resistant in areas infested with the FST would provide adequate protection for Type V structures, currently the most vulnerable to termite damage.

1. Louisiana State University. Termite Integrated Pest Management Series, "Formosan Subterranean Termite Damage and Detection". <http://www.agctr.lsu.edu/NR/rdonlyres/2FD93BF5-A2A8-4F89-BAA0-82EBD0B50232/3287/pub2840termitedetect8.pdf >
2. United States Department of Agriculture, Agriculture Research Service. National Formosan Subterranean Termite Program. <http://www.ars.usda.gov/is/br/fullstop/backgrounder.htm

Cost Impact: The code change proposal will likely increase the cost of construction.

Public Hearing:	Committee:	AS	AM	D
	Assembly:	ASF	AMF	DF

G166–06/07

Table 603 (New), 602.1, Table 601, 704.5, Table 704.8

Proponent: Jason T. Thompson, National Concrete Masonry Association (NCMA), representing Masonry Alliance for Codes and Standards (MACS)

1. Add new table as follows:

TABLE 603
FOR BUILDINGS IN SEISMIC DESIGN CATEGORIES C, D, E, and F
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, e]

FIRE SEPARATION DISTANCE = X (feet)	TYPE OF CONSTRUCTION	OCCUPANCY GROUP H	OCCUPANCY GROUP F-1, M, S-1	OCCUPANCY GROUP A, B, E, F-2, I, R[b], S-2, U[b]
X < 5[c]	I, III, IV II, V	4 4	4 3	4 2
5 ≤ X < 10	I, III IV II, V	3 2	3 1	2 1
10 ≤ X < 20	I, III, IV II, V	2 1	2 1	2[d] 1[d]
20 ≤ X < 30	I, III, IV II, V	1 1	1 0	1[d] 0
X ≥ 30	All	0	0	0

For SI: 1 foot = 304.8 mm.
1. a. Load-bearing exterior walls shall also comply with the fire-resistance rating requirements of Table 601.
2. b. For special requirements for Group U occupancies see Section 406.1.2.
3. c. See Section 705.1.1 for party walls.
4. d. Open parking garages complying with Section 406 shall not be required to have a fire-resistance rating.

e. The fire-resistance rating of an exterior wall is determined based upon the fire separation distance of the exterior wall and the story in which the wall is located.

2. Revise table as follows:

602.1 General. Buildings and structures erected or to be erected, altered or extended in height or area shall be classified in one of the five construction types defined in Sections 602.2 through 602.5. The building elements shall have a fire-resistance rating not less than that specified in Table 601 and exterior walls shall have a fire-resistance rating not less than that specified in Tables 602 and 603.

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[e]	B	A[e]	B	HT	A[e]	B
Nonbearing walls and partitions Exterior	See Tables 602 and 603								

(Portions of table not shown do not change)

704.5 Fire-resistance ratings. Exterior walls shall be fire-resistance rated in accordance with Tables 601, ~~and~~ 602 and 603. The fire-resistance rating of exterior walls with a fire separation distance of greater than 5 feet (1524 mm) shall be rated for exposure to fire from the inside. The fire-resistance rating of exterior walls with a fire separation distance of 5 feet (1524 mm)or less shall be rated for exposure to fire from both sides.

TABLE 704.8
MAXIMUM AREA OF EXTERIOR WALL OPENINGS[a]

(No changes to table text)
For SI: 1 foot = 304.8 mm.
a. through h. (No changes to current text)

i. Buildings whose exterior bearing wall, exterior nonbearing wall and exterior structural frame are not required to be fire-resistance rated by Tables 601, ~~or~~ 602 or 603 shall be permitted to have unlimited unprotected openings.
j. (No changes to current text)

Reason: This code change proposal attempts to address the significant potential for exterior fire spread from building to building in areas of the country that are subject to more significant seismic events. It has been well documented in recent earthquakes in California that fires follow major earthquakes. Probably the most well-known earthquake in this regard was the San Francisco earthquake in which occurred in 1906. That earthquake caused hundreds of fires which destroyed thousands of buildings within the city creating a virtual wasteland. It is somewhat ironic that this year is the 100th anniversary of that most dramatic and tragic earthquake. Of course, we've learned a lot since then about how to build buildings and how to protect them from fire. But we believe that the current Table 602 may prove to be inadequate to protect against a major conflagration, especially in concentrated downtown areas when the next significant earthquake strikes.

The numbers in this table are basically modeled after the fire-resistance ratings and separation distances for the for various types of construction and occupancies contained in the 1997 ICBO Uniform Building Code (UBC) since that is the code that is adopted and used throughout most of the states that have buildings in Seismic Design Categories C, D, E, and F. We chose to limit this table to those six seismic design categories to parallel Section 903.3.5.2 Secondary Water Supply. That section requires a secondary on-site water supply for high-rise buildings constructed in accordance with Section 403 when in Seismic Design Categories C, D, E, or F. If a secondary on-site water supply is necessary for high-rise buildings in these seismic design categories, we believe it is also an appropriate trigger for establishing higher fire-resistance ratings for exterior walls for those same buildings.

The basic philosophy for the fire-resistance ratings in this table is that the closer a building is to a property line or an adjacent building, the more fire-resistance should be provided to protect against potential exposure fires or to prevent a fire within a building from becoming an exposure fire to an adjacent building. Of course, this is similar to the concept in Table 602 where the closer a building is to an adjacent building or property line, the more severe the potential fire exposure will be. But in the case of buildings in seismic design categories C, D, E, and F, there is a major concern that fires may burn out of control since the fire department may not be able to respond to every fire in a timely manner. Their access may be disrupted by earthquake damage caused to roadways, bridges, and buildings that collapse across roadways blocking their access throughout their area of coverage. The fire department will also be spread very thin having to respond to many incidents virtually simultaneously or within close proximity to each other so they may find it extremely difficult, if not impossible, to respond to each and every fire incident. Thus, it can be expected that many fires will go uncontrolled and will need to be contained as long as possible within the structures in which they originate or be resisted by structures adjacent to those that have caught on fire in order to prevent building to building fire spread.

This is the reason for requiring 4-hour fire walls for virtually all types of construction for all occupancy groups that are located within 5 feet of an adjacent property line or building. Exterior walls with 4-hour fire-resistance ratings are also more substantial in construction since they are generally constructed of concrete or masonry. Therefore, there is a greater likelihood that they will also remain in place after the seismic event and be able to withstand the impact of any fires that occur subsequent to the seismic event. Another significant problem with earthquakes is that the water supplies are often disrupted as the water mains are ruptured and/or electric power is interrupted so there may not be pumps available to pump the water that might be available in the city water systems or the municipal water systems. Therefore, automatic sprinkler systems may not have water supplies available to deal with a fire that occurs in those buildings that are protected with sprinklers. Also, the fire department may not have adequate water to combat a fire within a building, thus having to fall back and protect adjacent structures from the fire within the building that is burning out of control. Therefore, we believe it is very important that the exterior walls have generally higher degrees of fire-resistance than is otherwise required by Table 602 based on fire separation distance where a building may be located in a Seismic Design Category C, D, E, or F.

Cost Impact: The code change proposal will increase the cost of construction.

Public Hearing:	Committee:	AS	AM	D
	Assembly:	ASF	AMF	DF

G167–06/07
603.1

Proponent: Marshall A. Klein, P.E., Marshall A. Klein and Associates, Inc., representing the Erickson Retirement Communities

Revise as follows:

603.1 Allowable materials. Combustible materials shall be permitted in buildings of Type I or Type II construction in the following applications and in accordance with Sections 603.1.1 through 603.1.3:

1. Fire-retardant-treated wood shall be permitted in:
   - 1.1. Nonbearing partitions where the required fire-resistance rating is 2 hours or less.
   - 1.2. Nonbearing exterior walls where no fire rating is required.
   - 1.3. Roof construction, including girders, trusses, framing and decking when the building is:
     1. Type I construction two stories or less in height above grade plane,
     2. Type I construction over two stories in height above grade plane and the vertical distance from the upper floor to the roof is 20 feet or more,
     3. Type II construction, or
     4. Type IB construction, sprinklered in accordance with Section 903.3.1.1, maximum of 7 stories (85 feet/26 m) in height above grade plane.

     ~~**Exception:** In buildings of Type I construction exceeding two stories in height, fire-retardant-treated wood is not permitted in roof construction when the vertical distance from the upper floor to the roof is less than 20 feet (6096 mm).~~

(Items 2 through 22 – no change to text)

Reason: The revisions shown in 1.3 (i), (ii), and (iii) are editorial and user friendly, replacing the existing exception with code text stating what *is* permitted, in place of code text stating what *is not* permitted.

The addition of 1.3(iv) is addressing use of FRT wood in roof construction of sprinklered buildings, which was quite common in certain parts of the United States. Proposed Part 1.3(iv) is a reasonable compromise between one of the legacy code's allowance under its height and area table. This proposal has the limitation set at 7 stories, with a max height of 85' to the mid point of the FRT wood trusses.

Prior to the drafting of the IBC, one of the legacy codes (BOCA) permitted the use of fire treated wood roof construction in buildings of Type 2A of all use groups. IBC Construction Type IB is basically equal to the old BOCA Type 2A, except that the old BOCA Type 2A required the floor construction to be 1½ hours, whereas IBC Type IB requires the floor construction to be 2 hours.

For example, the old BOCA Code permitted the use of fire treated wood roof construction in R-2 use buildings of Type 2A to be up to 10 stories in height (120') when sprinklered. It was very common that R-2 use buildings were built under this provision, since the appearance of the "pitched" roof is a desirable architectural feature. (Please see the attached Tables for the comparison of the BOCA Code Table 503 for Type 2A Construction vs. the IBC Table 503 for Type 1B Construction.)

FRT wood provided this desirable architectural feature, along with reasonable cost and fire resistance. NFPA 13, Section 8.14.1.2.11, has recognized for many years the superior fire resistance performance of FRT wood by its exception for sprinkler protection in concealed spaces (i.e. attics) that are constructed entirely of FRT wood. Acceptance of this use of FRT wood in roof construction of Type IB, sprinklered buildings, will not decrease the fire protection or life safety of the occupants. The acceptance of this code proposal will provide a reasonable, aesthetically pleasing, and cost conscious design alternative.

BOCA TABLE 503

USE GROUP Note A	Noncombustible Type 2 Protected 2A
A-1 Assembly, theaters	5 St. 65′ 19,950
A-2 Assembly, nightclubs and similar uses	3 St. 40′ 5,700
A-3 Assembly, lecture halls, recreational centers, terminals, restaurants other than nightclubs	5 St. 65′ 19,950
A-4 Assembly, churches Note c	5 St. 65′ 34,200
B Business	7 St. 85′ 34,200
E Education Note c	5 St. 65′ 34,200
F-1 Factory and industrial, moderate	6 St. 75′ 22,800
F-2 Factory and industrial, low Note h	7 St. 85′ 34,200
H-1 High-hazard, detonation hazards Notes e, i, k, l	1 St. 20′ 11,400
H-2 High hazard, deflagration hazards Notes e, i, k, l	3 St. 40′ 11,400
H-3 High hazard, physical hazards Notes e, i	6 St. 75′ 22,800
H-4 High hazard, health hazard Notes e, i	7 St. 85′ 34,200
I-1 Institutional, residential care	9 St. 100′ 19,950
I-2 Institutional, Incapacitated	4 St. 50′ 17,100
I-3 Institutional, restrained	4 St. 50′ 14,250
M Mercantile	6 St. 75′ 22,800
R-1 Residential, hotels	9 St. 100′ 22,800
R-2 Residential, multiple-family	9 St. 100′ 22,800
R-3 Residential, one- and two-family and multiple single-family	4 St. 50′ 22,800
S-1 Storage, moderate	5 St 65′ 19,950
S-2[b,c] Storage, low Note g	7 St. 85′ 34,200
U[c] Utility, miscellaneous	5 St. 65′ 19,950

IBC TABLE 503

GROUP	Height HGT(s)	TYPE I B
A-1	S A	5 UL
A-2	S A	11 UL
A-3	S A	11 UL
A-4	S A	11 UL
B	S A	11 UL
E	S A	5 UL
F-1	S A	11 UL
F-2	S A	11 UL
H-1	S A	1 16,500
H-2[d]	S A	3 16,500
H-3[d]	S A	6 60,000
H-4	S A	7 UL
I-1	S A	9 55,000
I-2	S A	4 UL
I-3	S A	4 UL
M	S A	11 UL
R-1	S A	11 UL
R-2	S A	11 UL
R-3	S A	11 UL
S-1	S A	11 48,000
S-2[b,c]	S A	11 79,000
U[c]	S A	5 35,000
A-5	S A	UL UL
H-5	S A	4 UL
I-4	S A	S 60,500
R-4	S A	11 UL

Cost Impact: The code change proposal will not increase the cost of construction.

Public Hearing:	Committee:	AS	AM	D
	Assembly:	ASF	AMF	DF