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Fire Safety: Building Construction Simplified

An Interactive Qualifying Project Report

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Bachelor of Science

by

Lawrence Phillip Byron

Christopher Puma

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Professor Leonard D. Albano, Major Advisor

Professor Robert W. Fitzgerald, Co-Advisor

Abstract

No tragedy exemplifies this event more than the World Trade Center disasters which alerted the world to the inhibition of predicting unstable structural situations involved in a major building fire. The purpose of this IQP is to develop the framework for a tutorial aiding firefighters with the concepts of building construction. Such a tutorial will be useful for firefighters to learn more about structural hazards during a fire leading eventually towards a greater understanding of building collapse.

Authorship

This IQP was with equal collaboration by Lawrence Byron and Christopher Puma.

While, working towards developing a final report for this IQP, both Lawrence Byron and Christopher Puma had specific areas of focus.

Lawrence Byron was responsible in creating the design and structure of this project's booklet and organizational tree.

Christopher Puma was responsible in developing this project's survey and critiquing Brannigan's *Building Construction for the Fire Service.*

Lawrence Phillip Byron

Christopher Puma

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1. Introduction

As the world's population steadily increases, our society's density parallels this trend forcing inhabitants into closer living quarters.[1] An urban sprawl, especially exemplified in the United States, creates a land race where new development seems to be shifting upwards instead of outwards due to the scarcity of land.[2] Naturally, taller and larger structures require more attentiveness to not only fire prevention but also to firefighting once incident occurs. Even with firefighting adapting a scientific approach, building collapse still cannot be predicted. The National Fire Prevention Association claims structural collapse to be one of the major increases in firefighter deaths.[3] No tragedy exemplifies this event more than the World Trade Center disasters which alerted the world to the inhibition of predicting unstable structural situations involved in a major building fire. The resulting collapse demonstrated a specific need for determining at what point, if any, a firefighter should enter or withdraw from a burning building. The purpose of this IQP is to develop the framework for a tutorial aiding firefighters with the concepts of building construction. Such a tutorial will be useful for firefighters to learn more about structural hazards during a fire leading eventually towards a greater understanding of building collapse.

1.1 Background

Structures serve human inhabitance through stability, protection from the elements, and human comfort. Building materials and construction techniques differ depending on the specific functionality of the structure concerning purpose and location. For example, concrete or steel, or even a combination of both, are chosen depending on loads within a structure, aesthetic intention, and cost during construction. Firefighters must, therefore, constantly alter their understanding of a building depending on how the composition of materials react during a fire. Many times, the properties of a building are never truly known, but must be inferred through an analytical procedure. The ability to look at a structure and

[1] Table 2 – PDF - http://www.census.gov/population/censusdata/table-2.pdf
[2] Population and Sprawl – Sierra Club - http://www.sierraclub.org/sprawl/population/
[3] fffstructure.pgf - http://www.nfpa.org/assets/files/PDF/fffstructure.pdf

recognize its specific building components, whether visible or not, leads to an assumption as to how a structure will react to fire.

Fire under certain conditions is extremely unpredictable do to complex properties of heat and energy.[4] Even the ability to control fire is sometimes quite impossible during unfavorable environmental conditions or involving combustible materials. Fire still, however, is at the mercy of the conditions around it. A lack of oxygen or combustion can hamper a fire's growth and path throughout a structure. Naturally, firefighters must understand the interaction between fire and a structure to be successful in fire suppression and life safety. This resulting situation prompted the firefighting profession to begin questioning more about the building constructure in their communities. New policies are being adapted to bring the fire department's attention to potentially dangerous buildings. Cities, such as New York, have even gone as far to propose new laws requiring all wood truss buildings to be properly identified in order to prevent fire personnel from entering.[5] This increasing prevention in regards to structural collapse allows for the adaptation of new techniques or ways of understanding the building environment under fire conditions.

1.2 Problem Statement

Currently, there is no failsafe method available for firefighters to predict potential building hazards resulting from fire duress. One of the greatest problems involved in a structural fire is the possibility of collapse. An interview with Chief Calloray of the Worcester Fire Department revealed firefighters use their experience and instincts to avoid these situations (*Appendix II*). These techniques are impractical considering each building is uniquely constructed and each firefighter has different experiences and ways of thinking. What may be considered dangerous to one firefighter might not be to another. Therefore, many times structural stability cannot be determined because there is no set standard to judge from.

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[4] NAP Skim View of: Chapter 6, Fire Properties of Materials - http://www.nap.edu/nap-cgi/skimit.cgi?isbn=0309053366&chap=61-92

[5] Presentations Made at the Mayoral Code Commission Public Forum - http://www.nyc.gov/html/dob/html/dunn.html

2. Research

Researching began with the development of a survey asking to the extent of training given to firefighters, reference material used, and time devoted to building construction (*Appendix III*). Fifty of these surveys were sent to metropolitan fire departments in all regions across the country (*Appendix IV*). Surveying multiple fire houses within each city minimized the likelihood of receiving outlying data. A limited number of survey responses concluded building construction to be present in all training curriculums (*Appendix V*). Many times, however, building construction was not the focal point of these teachings or referenced material (*Appendix V*). With only a narrow response it was necessary to see how accurate the data reflected the fire profession. An interview with Training Chief Giard from the Worcester Fire Department confirmed that building construction was touched upon but the lack of funding and classroom time only allowed for the more practical aspects of it (*Appendix I*).

Before developing a tutorial, it was also imperative to first learn about the intended target audience. Firefighters were found to have minimal education as it really did not pertain to their job. Rarely do firefighters obtain a college education, although numbers are still increasing with more competition into entering fire departments.[6] Usually, a fireman's salary reflects somewhat of his educational background averaging around $17.42 an hour. [7] With such a minimal salary, most find themselves required to learn a trade for additional income. Therefore, a tutorial should reflect an audience with limited time and attentiveness to mathematics and quantitative analysis. Any created tutorial should minimize the use of lengthy paragraph form while still incorporating detailed ideas and pictures.

2.1 Becoming a Firefighter

To become a firefighter it is necessary to complete a high school diploma or GED; pass a written exam; pass a physical test; pass a medical exam; and complete firefighter training *(Appendix IX)*. [8] Probationary firefighters are rookies who have not yet accomplished the necessary training qualifications

[6] 40 Applicants for Every Position As a Fireman? - http://www.greenend.org.uk/rjk/2002/11/firemen.html
[7] Firefighter Occupations - http://stats.bls.gov/oco/ocos158.htm
[8] Department of Fire Services, Massachusetts - http://www.mass.gov/dfs/index.shtm

and experience needed to be classified as full-time firefighters. The probationary period usually lasts six months before tenured status can be achieved.[9] Training is either held at in-house locations within the fire department or at state fire academies. The requirements for training include both a classroom styled course and hands-on fire training within practice buildings (*Appendix X)*. Any person who passes these initial conditions required to become a firefighter has the opportunity to face the dangers of a building fire even though many still know nothing about building construction or structures to any extent. Textbooks used in various training courses such as *Fire Essentials* divulge little to any time on the subject. Most will never even take time to read *Building Construction for the Fire Service*, yet all will face the dangerous conditions with moderate experience and no knowledge of how building construction applies to firefighting.

Similar to the police force, fire departments have a certain hierarchy within (*Appendix VIII*). The chain of command for firefighters is established to reflect and address responsibility during ground operations. Higher ranked fire officials are responsible for coordinating the important actions of lower ranked firefighters such as movement within or around a building fire.[10] To progress throughout the ranks within a fire department it is necessary to show progression in field operations, recommendations, and additional education and certification usually held at the state fire academy.[11] The desire in progressing up the chain of command shows an interest and aptitude in learning about more in-depth techniques from around the country. These additional courses are required to help firefighters become more proficient in firefighting as well as life safety on the job. Supplemental material on building construction, however, is few and far between making a given tutorial an excellent addition to these courses. Chief Giard confirmed that such a tutorial could be used in the training curriculum as national trends shape the direction of firefighting but do not dictate lesson material (*AppendixI)*.

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[9] MGL – Chapter 31, Section 34 - http://www.mass.gov/legis/laws/mgl/31-34.htm
[10] Incident Command System Training Manual - http://ema.arrl.org/fd/ICS_TM.htm
[11] SOV -1-V-22 Promotion Policy - http://www.cfdonline.org/book1/1-v-22.htm

2.2 Brannigan

Upon researching responses collected from the surveys and interviews, an important reference for firefighters was discovered. Frank Brannigan's *Building Construction for the Fire Service* is considered the forefront in teaching building construction to firefighters. A pioneer for using a different approach in analyzing building hazards, Brannigan with his book quickly sold more than 130,000 copies and remains as the "bible" for firefighters to follow.[12] This monumental text was the first to utilize pictures from actual structural fires along with analytical text to show firefighters the many dangers a building can pose.

While the content of *Building Construction for the Fire Service* provided excellent photographic evidence towards the books purpose, the organization of the book seemed ill contrived. Building construction as previously examined in chapter 1.1 becomes far too complex without showing the interaction between building components. The table of contents of *Building Construction for the Fire Service* does not follow any orderliness towards the composition of a building (*Appendix XII*). For example, building construction materials are used as the pretext in chapters on steel, stone, and wood but do not properly follow through in the remaining chapters. The lack of development within building components is extremely confusing as Brannigan's book jumps throughout different structures Understanding how building construction can lead to structural collapse is next to impossible without properly showing correlation between building hazards.

While Brannigan offers many examples of building hazards faced by firefighters, he does not explain how certain incidents could occur. Instead, he merely mentions certain conditions that lead to particular hazards. Using this practical approach provides firefighters with just enough understanding to hopefully recognize an incident before it occurs, but does not prompt an overall awareness of the danger. Chief Giard further explains that he would prefer to understand both how and why certain events occur within a building fire (*Appendix I*). A newly contrived tutorial should therefore contain more in-depth details concerning certain hazards within a building. Not only will this give firefighters a better idea of

[12] Construction Guru – Francis Brannigan - http://firechief.com/mag/firefighting_construction_guru_francis/

what they are facing but it is also useful in predicting times of instability. Knowing how the implications from certain occurrences could jeopardize a structure overall will greatly benefit firefighters.

Another fault with Brannigan's book lies in his approach towards the firefighters. Response from the surveys and interviews show that the majority of firefighters have little time and willingness to read such lengthy books (see *Appendix I, II, and V*). While the use of pictures seems to be an excellent method in captivating his audience, most firefighters are still only willing to spend thirty minutes to an hour on supplement material (see *Appendix I and V*). *Building Construction for the Fire Service* was best suited the times during the 1970s when it was first published. The advent of programs such as PowerPoint or Macromedia Flash allow for much faster and captivating teaching as computer learning is becoming ever more popular.[13] The possibility of interaction incorporated into such multimedia gives firefighters a hands-on learning tool. These multimedia techniques, however, can be hampered due to limited computer and internet access at fire stations. Survey results proved this wasn't a major factor but Chief Giard did mention the fact that the Worcester Fire Department had practically no access to computer technology (*Appendix I*). Using a hardcopy formed tutorial would be ideal for reaching smaller fire stations with limited budgeting and an older target audience who have not yet adapted to newer technology.

2.3 Implications

The use of different research techniques unveiled an in-depth understanding of firefighters. Realizing the limited extent of the average firefighter's education set limitations to the context of a future tutorial. For example, the survey indicated that time restrictions are necessary in keeping the attention of firefighters (*Appendix V*). Using practical examples including a combination of both pictures and text in addition to interrelating different building components to the wholeness of a structure was gathered from interviews with Chiefs Calloray and Giard. The overall creation of such a tutorial should be created using

[13] Editorial: Organizational Strategies - http://www.cdwg.com/webcontent/editorialg/organizational/070801_TechnologyTacklesCrimeFireAndDisaster.asp

methods relating towards present times. Therefore some form of multimedia is beneficial for conveying the tutorial. A hardcopy version should, however, be available due to limited computer and internet access at different localities (*Appendix I*). Brannigan's *Building Construction for the Fire Service* serves as an excellent model for developing a tutorial on building construction. A clearer method of organizing the different components of building construction is needed to captivate firefighters.

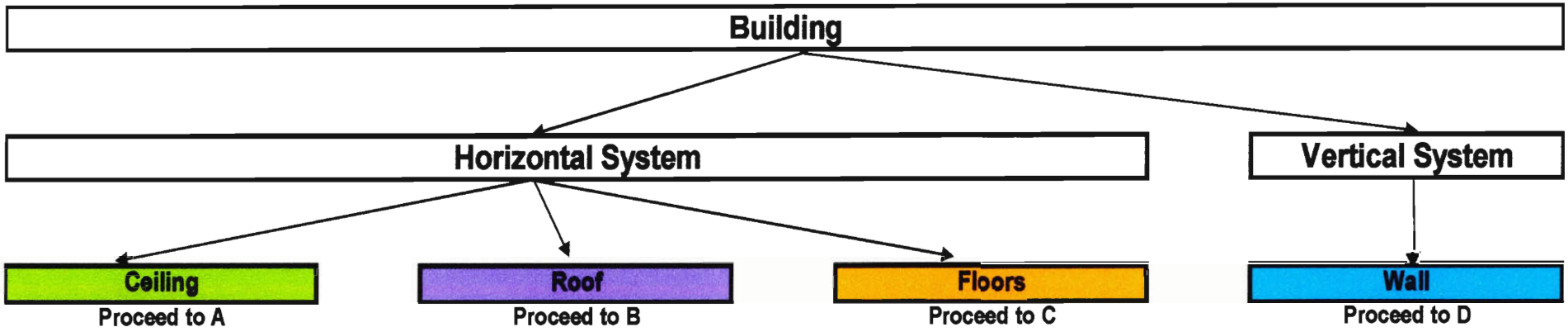
3. Solution

Research proved our original intentions for a creating a tutorial are justified as a clear need for teaching building construction to be an issue across the country and not an isolated problem. Furthermore, interviews at the Worcester Fire Department showed firefighters had a willingness to learn about building construction with a practical usage. Information gathered, required any such tutorial to be quickly reviewed in under and hour. Problems with current educational text books are the times constraints for reading, complex concepts and poor organization of building components. All these issues must be considered before the creation of a tutorial.

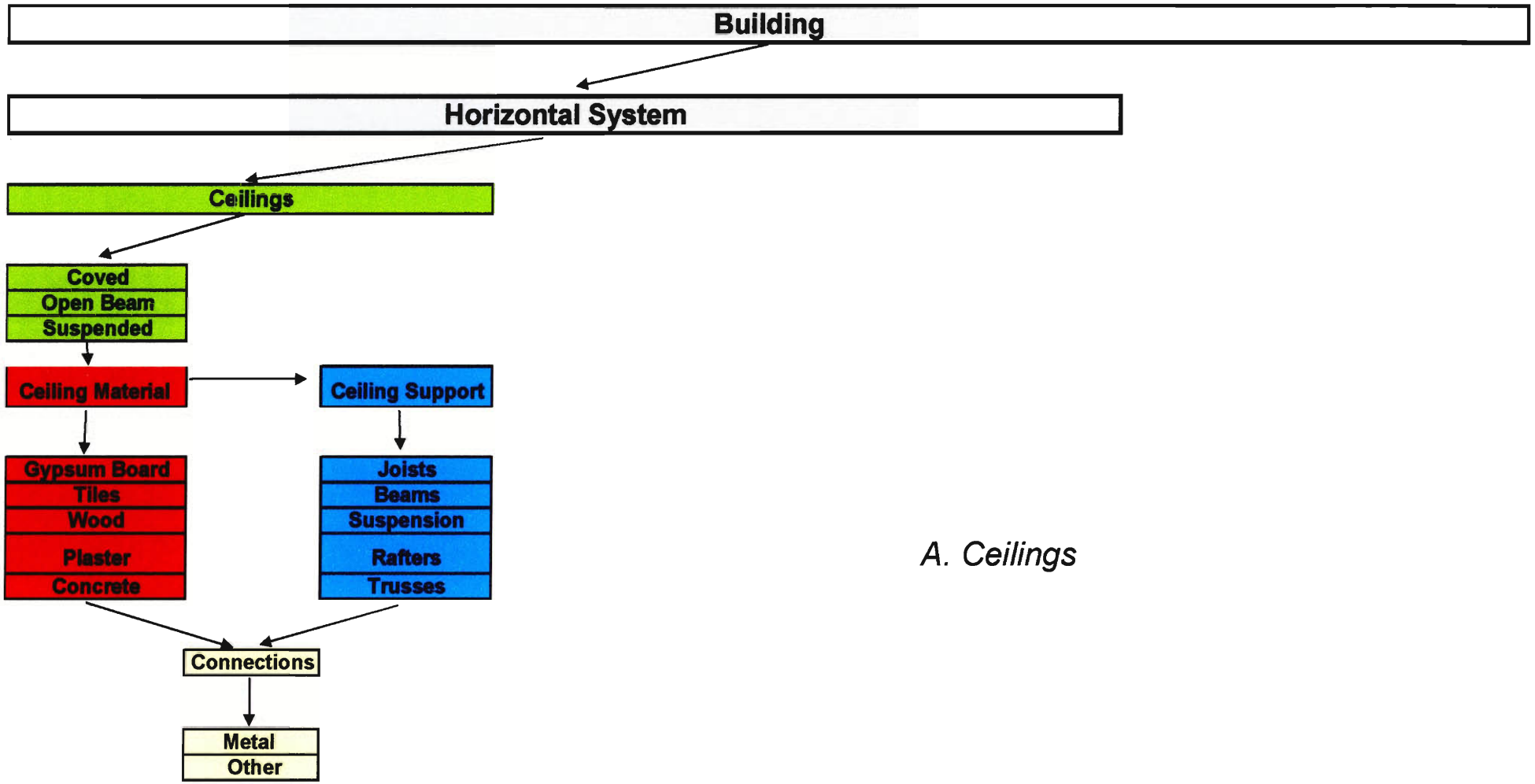
3.1 Design of an Organizational Tree

The organization of different building construction components is imperative in developing a coherent tutorial. Developing an organizational tree is helpful in not only showing the overall interaction of the tutorial but also showing how firefighters could infer what building hazards are present through analysis of visible characteristics from a building. This organization tree must also apply to every aspect of building construction including different building types.

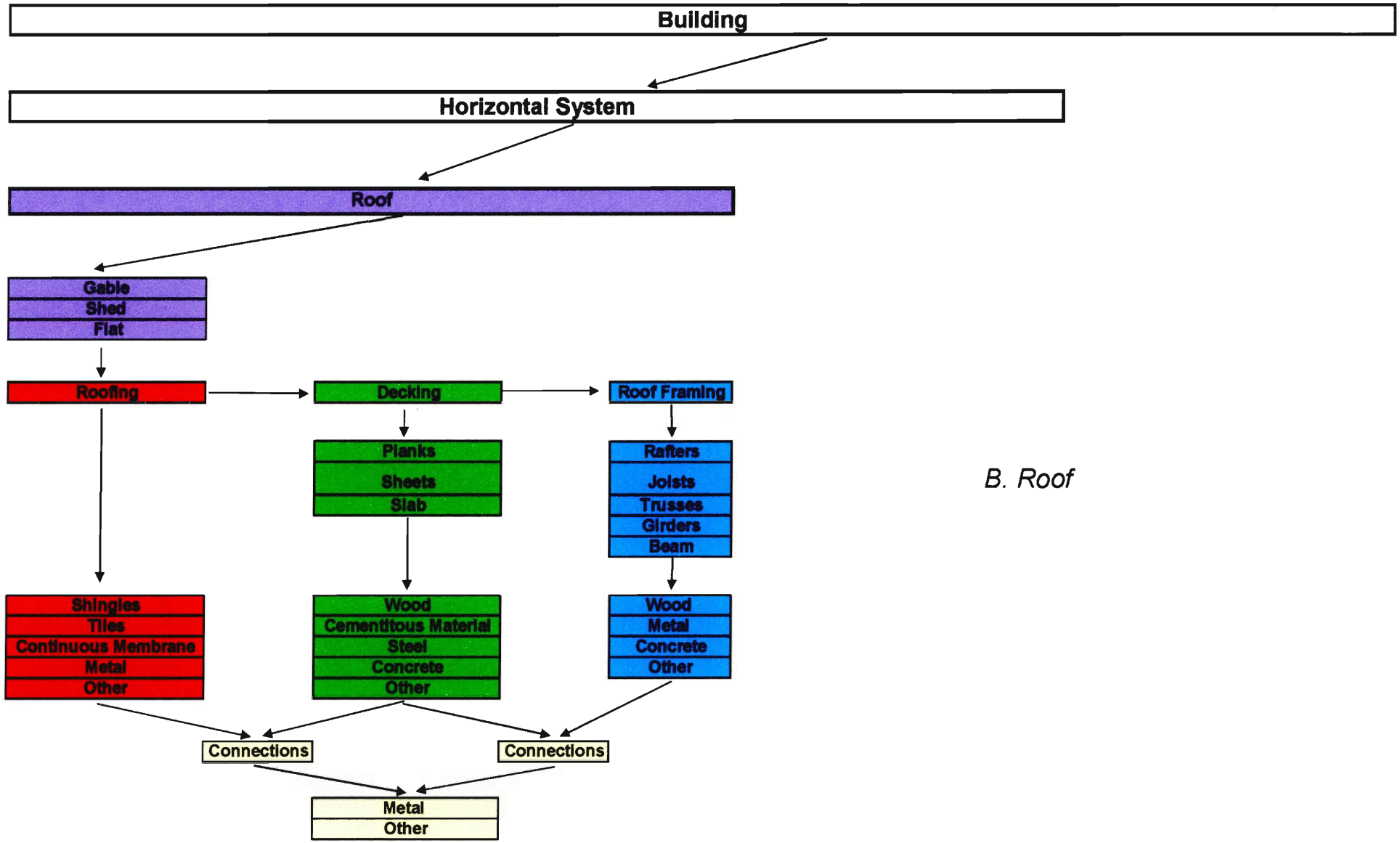
The underlying technique used in making an organizational tree was to label every part of a building based on its classification as a vertical or horizontal systems (*Appendix VI*). For example, walls are located under vertical systems while floors under horizontal systems. This method of organization allows for different building components to be classified in the tree as vertical or horizontal in purpose. An organizational chart could be considered successful if different examples of building construction are easily located on the tree. Initial attempts at the organization tree were far to complex to follow and revision was necessary. A number of different revisions, seen in *Appendix VI and VII*, led to the finalized tree on the following page.



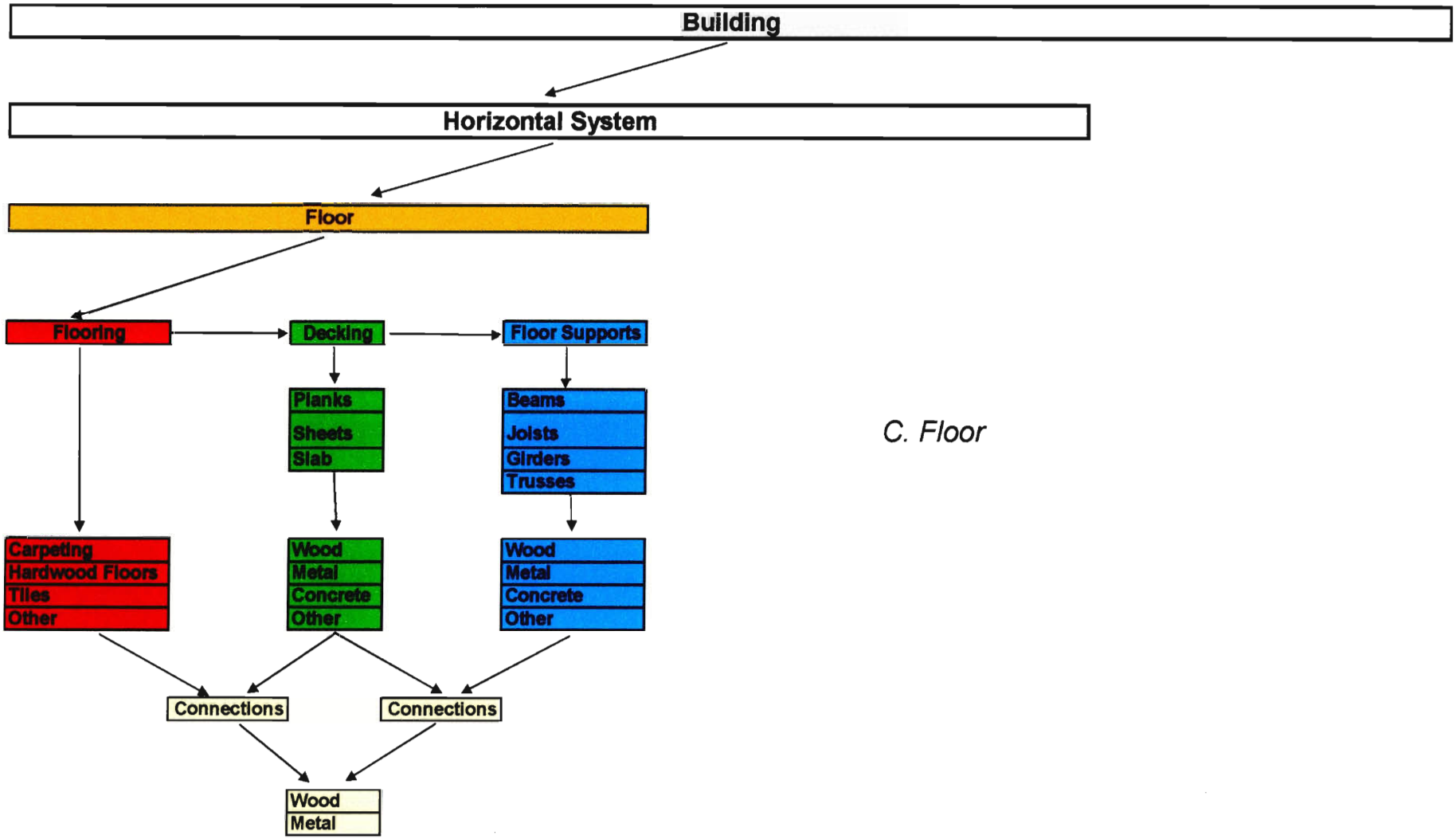
Organizational Tree Overview


Building
Horizontal System
Ceilings
Coved
Open Beam
Suspended
Ceiling Material
Ceiling Support
Gypsum Board
Tiles
Wood
Plaster
Concrete
Joists
Beams
Suspension
Rafters
Trusses
Connections
Metal
Other

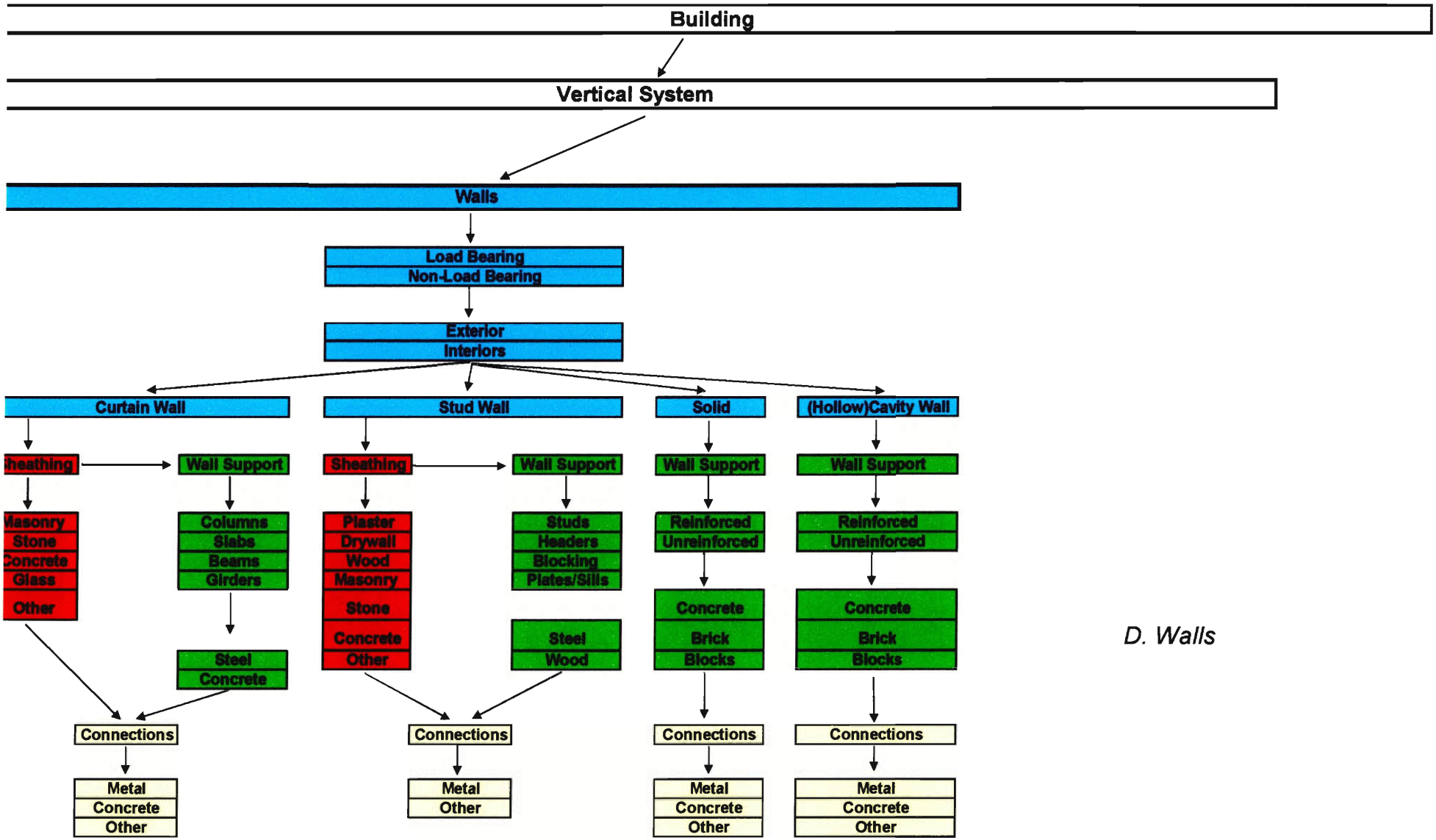
A. Ceilings


Building
Horizontal System
Roof
Gable
Shed
Flat
Roofing
Decking
Roof Framing
Planks
Sheets
Slab
Rafters
Joists
Trusses
Girders
Beam
Shingles
Tiles
Continuous Membrane
Metal
Other
Wood
Cementitous Material
Steel
Concrete
Other
Wood
Metal
Concrete
Other
Connections
Connections
Metal
Other

B. Roof


Building
Horizontal System
Floor
Flooring
Decking
Floor Supports
Planks
Sheets
Slab
Beams
Joists
Girders
Trusses
Carpeting
Hardwood Floors
Tiles
Other
Wood
Metal
Concrete
Other
Wood
Metal
Concrete
Other
Connections
Connections
Wood
Metal

C. Floor


Building
Vertical System
Walls
Load Bearing
Non-Load Bearing
Exterior
Interiors
Curtain Wall
Stud Wall
Solid
(Hollow)Cavity Wall
heathing
Wall Support
Sheathing
Wall Support
Wall Support
Wall Support
Masonry
Stone
Concrete
Glass
Other
Columns
Slabs
Beams
Girders
Plaster
Drywall
Wood
Masonry
Stone
Concrete
Other
Studs
Headers
Blocking
Plates/Sills
Reinforced
Unreinforced
Reinforced
Unreinforced
Concrete
Brick
Blocks
Concrete
Brick
Blocks
Steel
Concrete
Steel
Wood
Connections
Connections
Connections
Connections
Metal
Concrete
Other
Metal
Other
Metal
Concrete
Other
Metal
Concrete
Other

D. Walls

Not only does this method of organization take into account the various components of building construction, but it also clearly contains valuable areas for connection and materials. Testing the tree proved successful, allowing for a fully developed branch in tutorial form.

3.2 Creation of a Tutorial

Floor systems were chosen from the organizational tree to develop part of the future tutorial. Considering the implications from previous research, the tutorial utilizes the use of real-life photographs and simplified sketches to aid presented concepts within the text (*Appendix XI*). Included concepts to the fundamentals of building adhere to the organizational tree's layout, breaking down each system into a series of layers – i.e. supports, decking, material, etc... The ability to recognize how a building is actually constructed will be taken from the tutorial, leaving firefighters with a sense of how the hazards Brannigan includes in *Building Construction for the Fire Service* correspond to the different parts of a building. This understanding is the first step in recognizing the characteristics of building collapse.

4. Conclusion

A developed tutorial adhering to the principles of the aforementioned organizational tree along with the understanding of firefighters will be successful as the first step in educating firefighters about structural collapse. A better grasp of how buildings are constructed and the implications under fire conditions will also allow for more in-depth training on building fires. Laying the framework in an easily understood but still detailed fashion is crucial in protecting life safety as experience can always be refined with scientific procedure. After all, firefighters are at the mercy of their surroundings.

Bibliography

Books Used:

Brannigan, Francis L.. Building Construction for the Fire Service. Second Edition. 1982

Ching, Francis D.K.. Building Construction Illustrated. New York: Van Nostrand Reinhold Company, 1975.

The International Fire Service Training Association. Essentials of Firefighting. Fourth Edition. Oklahoma: Fire Protection Publications, Oklahoma State University, 1998.

National Academy of Sciences—National Research Council. Insulated Masonry Cavity Walls. 1960

Internet Sites Used:

40 Applicants for Every Position as a Fireman? - http://www.greenend.org.uk/rjk/2002/11/firemen.html

Construction Guru – Francis Brannigan - http://firechief.com/mag/firefighting_construction_guru_francis/

Department of Fire Services, Massachusetts - http://www.mass.gov/dfs/index.shtm

Editorial: Organizational Strategies - http://www.cdwg.com/webcontent/editorialg/organizational/070801_TechnologyTacklesCrimeFireAndDisaster.asp

fffstructure.pgf - http://www.nfpa.org/assets/files/PDF/fffstructure.pdf

Firefighter Occupations - http://stats.bls.gov/oco/ocos158.htm

Incident Command System Training Manual - http://ema.arrl.org/fd/ICS_TM.htm

MGL – Chapter 31, Section 34 - http://www.mass.gov/legis/laws/mgl/31-34.htm

NAP Skim View of: Chapter 6, Fire Properties of Materials - http://www.nap.edu/nap-cgi/skimit.cgi?isbn=0309053366&chap=61-92

Population and Sprawl – Sierra Club - http://www.sierraclub.org/sprawl/population/

Presentations Made at the Mayoral Code Commission Public Forum - http://www.nyc.gov/html/dob/html/dunn.html

SOV -1-V-22 Promotion Policy - http://www.cfdonline.org/book1/1-v-22.htm

Table 2 – PDF - http://www.census.gov/population/censusdata/table-2.pdf

Appendix I

Interview with Chief Giard

Chief Giard – Training Chief, Worcester Fire Department

1st Interview:

Our initial meeting with Chief Giard was to introduce him to our project's survey to gain any feedback concerning how it could be used to help our project. Unfortunately, he was extremely confused to the exact nature of our survey, specifically how it applies to our project in general. Firefighters, in his opinion, could not practically use the analytical principles of building construction as we presented in analytical form. Instead, a better use for integrating aspects of building construction to firefighting could potentially deal with predicting a structural collapse through scientific analysis. Maybe, he informed us, it would more helpful to interview Chief Calloray because of his academic background being more adapted to use such analytical conceptualization.

Another difficulty in the multimedia project we were proposing was that lack of funding within the Worcester Fire Department limiting computer access. Such a problem could potentially hamper using distributing a computer based tutorial. Chief Giard even informed us that district training was a monumental procedure given at the only place with multimedia capability within Worcester - central INS department at police headquarters. Classes were limited to roughly 20-30 students due to room size and computer access. Chief Giard, in fact, had to hold these classes several times a year to accommodate all the firefighters within the department.

Interestingly, the subject material of these classes was based on the discretion of Chief Giard but still influenced by incidents and current trends within fire fighting across the country. For example, the tragedy involving 4 civilians in a Chicago high rise department prompted the Worcester Fire Department to offer a mandatory course in high rise fire suppression. Most of fire fighters we learned limited educational backgrounds mostly pertaining to some sort of high school or GED equivalent. Concluding our interview, Chief Giard explained the Worcester Fire Department was extremely familiar with new technology, especially with thermal imagery equipment donated to their station after the tragedy in 1998. He was not in any way reluctant to use or familiarize with growing industry trends.

2nd Interview:

We received a course outline from Chief Giard and learned budget cuts forced the next Worcester Fire Fighting class to be postponed until next year. We briefly talked about some structural principles such how metal deformation and structural stability applied to his job. We learned that Chief Giard understood why certain incidents such as metal deformation occurred but not particularly how they occurred. He would be interested in finding out about these concepts but stressed it wouldn't particularly help him at his job or to be safer in during fire suppression.

Appendix II

Interview with Chief Calloray

Chief Calloray – District Chief, Worcester Fire Department

1st Interview:

Chief Calloray informed us that a tutorial based on academic concepts relating to building construction would not be useful to the fire fighting community especially with Brannigan's book being the "bible" of building construction in firefighting. We did not in fact "invent the wheel" as he put it. The only reason Brannigan's book was so useful was the photos he had to back up his concepts. We then talked about what medium would be useful if we were to present something to the fire department. He responded that it would differ from person to person but through his own experience he believed older fire personnel would prefer written material instead. We then asked about who was in command during fire suppression; specifically who gave orders to knock down certain walls, etc... Fire suppression procedures were based more on experience that scientific method in the field. We also briefly talked about the life of a firefighter and he added most firefighters are tradesman to bring home additional income.

Appendix III

Initial Survey

Chief _____ ,

Enclosed is a survey to determine if the concepts of building construction are being incorporated into actual firefighter training. An understanding of this relationship can be useful in developing scientific methods for predicting structural collapse and failure during fire suppression.

There is also a self addressed envelope to return surveys in.

Estimated time of survey: 5 minutes.

Thank you for your time!

cpuma@wpi.edu 978 333 9444

Worcester Polytechnic Institute
Civil Engineering/Fire Engineering

Worcester Polytechnic Institute Survey
Civil Engineering / Fire Engineering Departments

Purpose:
- gain a better understanding of the in-house training used at fire departments across the country

Does your fire department utilize in-house training?

☐ Yes ☐ No

Most of the firefighting personnel under your command have received what extent of initial firefighter training?

☐ In-house Training ☐ State Fire Academy ☐ Community College

☐ Other: _____

How is the in-house training at your fire department structured?

☐ Mostly Classroom ☐ Actual "Hands On" Simulations

☐ Classroom and Simulations

Does your training school offer any courses which involve discussion of building construction and/or structural hazards? Please check the choices that apply.

☐ Yes, a course discussing building construction and/or structural hazards alone.
☐ Yes, a course partially devoted to building construction and/or structural hazards.
☐ No, principles of building construction and/or structural hazards are not taught.

What textbook(s) are used in these courses? Please check all that apply.
☐ *Building Construction for the Fire Service* (Brannigan)
☐ *Collapse of Burning Buildings* (Dunn)
☐ *Essentials of Fire Fighting* (Hall)
☐ Not Applicable
Others, please list: _____

Do you regularly look for new advancements in the firefighting profession on your own time?
☐ Yes ☐ No if yes, proceed:
☐ Magazines ☐ Journals ☐ Videos ☐ More education
☐ Internet resources Other _____

If yes, about how long do you spend on such materials?

☐ 0-30 minutes ☐ 30 minutes – 1 hour ☐ 1-2 hours ☐ 2+ hours

Where do you have access to a computer and the internet? ☐ No or Restricted Access
☐ Internet access at firehouse ☐ Internet access at home ☐ Both

Appendix IV

City List for Surveys

Chicago Fire Department
Chief Battalion 4

Chicago Fire Department
Chief Battalion 5

Chicago Fire Department
Chief Battalion 8

Chicago Fire Department
Chief Battalion 11

Chicago Fire Department
Chief Battalion 17

Chief Sherman George
Fire Commissioner and Chief
Department of Public Safety

Denver Fire Department
Station 1 - District 2

Denver Fire Department
Station 3 - District 2

Denver Fire Department
Station 4 - District 2

Denver Fire Department
Station 6 -District 2

Denver Fire Department
Station 7 - District 6

East Providence Fire Department
913 Broadway

Fort Worth Fire Department
120 N. Pecan

Fort Worth Fire Department
1000 Cherry

Fort Worth Fire Department
4700 Ramey

Houston Fire Department
Fire Station 2

Houston Fire Department
Fire Station 3

Houston Fire Department
Fire Station 4

Indianapolis Fire Department
Station 01

Indianapolis Fire Department
Station 02

Indianapolis Fire Department
Station 16

Los Angeles Fire Department
Fire Station 1

Los Angeles Fire Department
Fire Station 2

Los Angeles Fire Department
Fire Station 3

Los Angeles Fire Department
Fire Station 4

Los Angeles Fire Department
Fire Station 5

Los Angeles Fire Department
Fire Station 6

Milwaukee Fire Department
784 N. Broadway,

Milwaukee Fire Department
1400 S. 9th Street

Milwaukee Fire Department
1313 W. Reservoir Avenue

Philadelphia Fire Department
711-23 South Broad St

Philadelphia Fire Department
2600 S. 13th Street

Philadelphia Fire Department
801 S. 52nd Street

Philadelphia Fire Department
4221-29 Market Street

Portland Fire Department
Munjoy Hill Station

Portland Fire Department
Bramhall Station

Richmond Fire Department
1018 Williamsburg Rd

Richmond Fire Deparment
1235 N 28th St

Richmond Fire Department
3901 Chamberlayne Ave

Richmond Fire Department
138s S Jefferson St

San Diego Fire Department
Station 1

San Diego Fire Department
Station 3

San Diego Fire Department
Station 4

St Louis Fire Department
1421 N Jefferson Ave

Washington DC Fire Department
3rd Battalion

Washington DC Fire Department
4th Battalion

Washington DC Fire Department
5th Battalion

Washington DC Fire Department
6th Battalion

Appendix V

Survey Results

Surveys Responded: 10

Does your fire department utilize in-house training?
(10) Yes 0 (0) No

Most of the firefighting personnel under your command have received what extent of initial firefighter training?
(6) In-house Training (7) State Fire Academy (1) Community College
Conclusion: In-House Training and State Fire Academy were the most popular methods for training firefighters.

How is the in-house training at your fire department structured?
(1) Mostly Classroom (1) Actual "Hands On" Simulations (8) Classroom and Simulations

Does your training school offer any courses which involve discussion of building construction and/or structural hazards? Please check the choices that apply.
(3) Yes, a course discussing building construction and/or structural hazards alone.
(7) Yes, a course partially devoted to building construction and/or structural hazards.
(0) No, principles of building construction and/or structural hazards are not taught.

What textbook(s) are used in these courses? Please check all that apply.
(6) *Building Construction for the Fire Service* (Brannigan)
(3) Collapse of Burning Buildings (Dunn)
(8) Essentials of Fire Fighting (Hall)

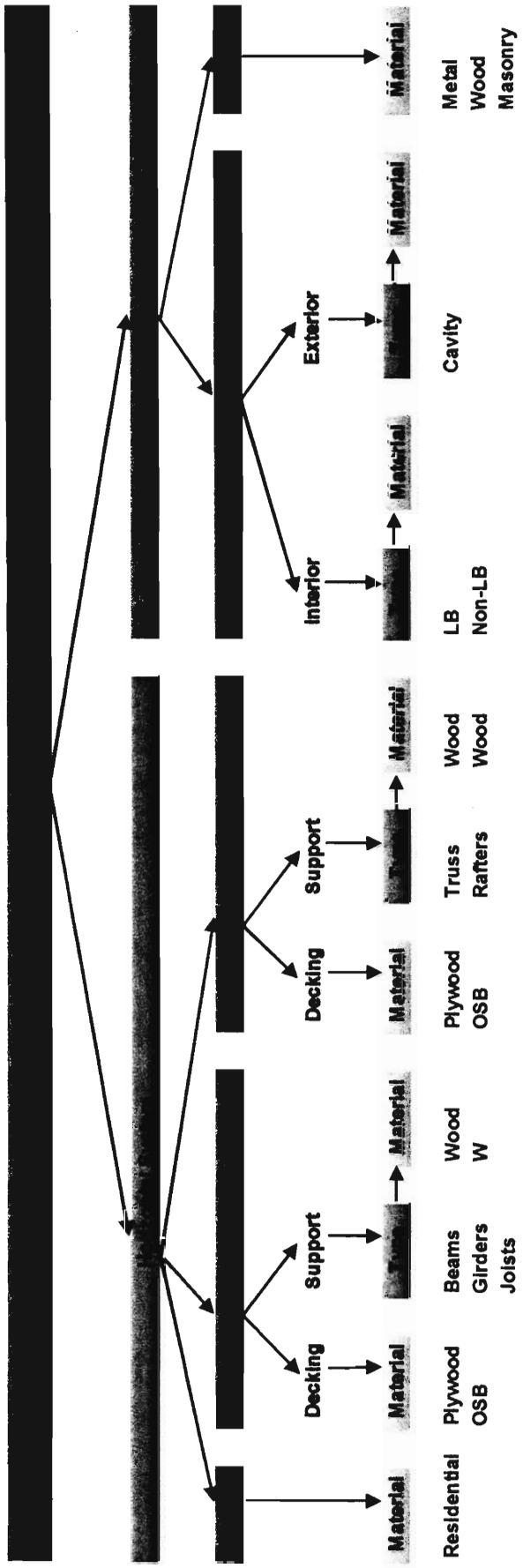
Do you regularly look for new advancements in the firefighting profession on your own time?
(9) Yes (1) No if yes, proceed:
(9) Magazines (3) Journals (3) Videos (5) M ore education (7) Internet resources

If yes, about how long do you spend on such materials?
(0) 0-30 minutes (4) 30 minutes - 1 hour (2) 1-2 hours (2) 2+ hours

Where do you have access to a computer and the internet? (0) No or Restricted Access
(1) Internet access at firehouse (1) Internet access at home (8) Both

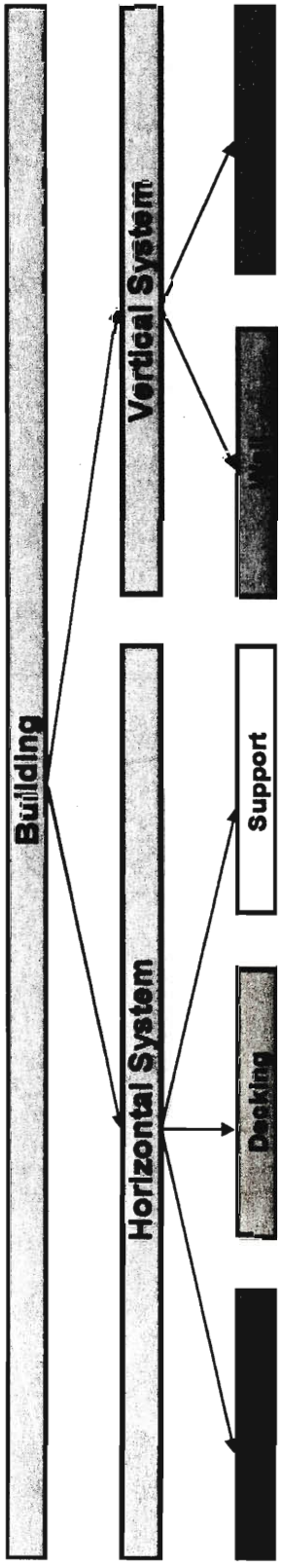
Appendix VI

Organization Tree (First Draft)



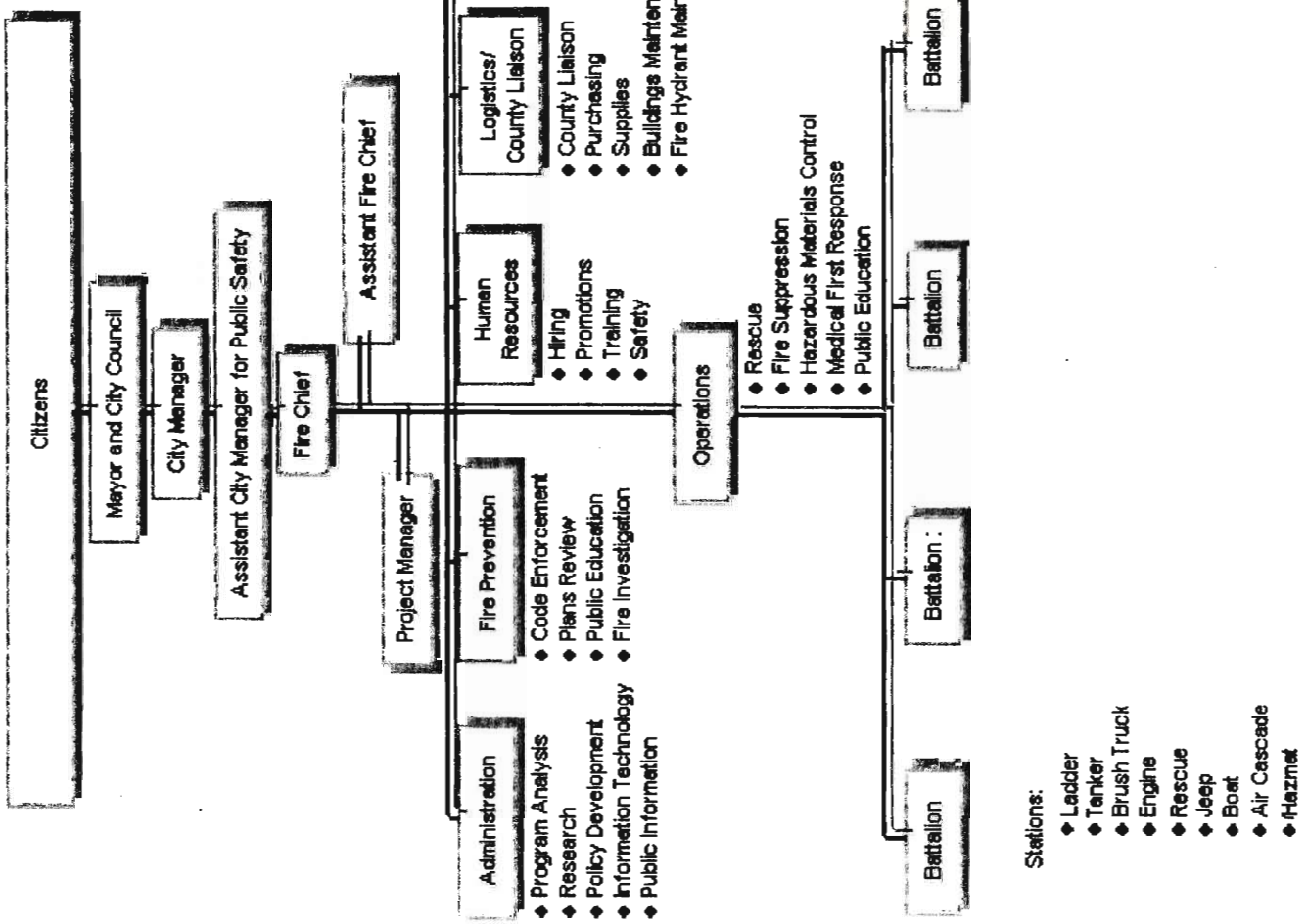
Appendix VII

Organization Tree (Over Simplified Second Draft)



Appendix VIII

General Hierarchy Chart



Appendix IX

Required Qualifications

- Minimum age: 18 (at the time that you apply)
- Must have a valid driver's license from state of residence, with a reasonable driving record.
- Must have a high school diploma or G.E.D. Certificate.
- Must pass a rigid physical examination and drug screen.
- Applicant's record may not include: conviction of a felony involving moral turpitude; one general court martial or more than one incidental court martial.
- Must be a United States citizen or an alien who can provide proof of identity and authorization to work in the United States.
- Residency- No residency requirements presently exist.

Preferred Qualifications

- Clean driving record
- College experience with a degree
- EMT-Basic Certification
- Physically ready to meet the final requirements of the Training Abilities Course at time of entry
- Some firefighting experience

Appendix X

Training Track Suggestions

FIREFIGHTER BASIC SKILLS

Asbestos and the Firefighter
Automatic Sprinkler Systems
Critical Incident Stress
Electricity
Elevators and the Fire Service
Emergency Elevator Procedures
Fire Control I
Fire Control II
Firefighter IA
Firefighter IB
Firefighter IC
Firefighter ID
Firefighter IE
Firefighter IF
Firefighter IIA
Firefighter IIB
Firefighter IIC
Fireground Company Operations
First Due
Fighting Fires in Sprinklered Buildings
Firefighter Safety and Survival
Flammable Liquids
Foam
Handling Gas Emergencies
Hazardous Materials Recognition and Identification
Interior Fire Attack
Incident Command System
Protective Breathing
Search and Rescue
Recruit Firefighter
Training
Safety for the Firefighter
Search and Rescue
Structural Firefighting Practices
Structural Hazards
Small Aircraft Procedures
Vehicle Extrication (Basic)
Vehicle Fires
Wildfires

FIRE APPARATUS DRIVER/OPERATOR

Aerial Apparatus
Large Diameter Hose
Motor Pump Operator
Pumps and Hydraulics
Rural Water Supply

FIRE & ARSON INVESTIGATION

Arson Awareness for the First Responder
Basic Fire Investigation
Interviewing Skills
Advanced Fire Investigation

EMERGENCY MEDICAL SERVICE

(These courses are submitted for OEMS approval for EMT Continuing Education annually.)

The Law and the EMT
Domestic Preparedness Tech
Pre-Hospital Burn Treatment
Infectious Disease Control for the First Responder
ICS for EMS
Air Medical Protocols for Fire Departments
Strategies for EMS in the Fire Service
Rehab
Drowning/Near Drowning
Crush Injury Syndrome
Chest Trauma Management
Sudden Infant Death Syndrome
Cardiac Emergencies

FIRE PREVENTION

Building Construction - Wood and Ordinary Construction
Building Construction - Non-Combustible and Fire Resistive Construction
Conducting Basic Fire Inspections
Fire Inspection and Code Enforcement Practices
Public Fire Education Planning
Public Fire and Lifesafety Educator
Public Education Presentation

HAZARDOUS MATERIALS

Chemistry of Hazardous Materials
Flammable Gas Firefighting
Flammable Liquids
Handling Gas Emergencies
HazMat Recognition and Identification
Hazardous Materials Incident Analysis
Hazardous Materials First Responder Operational
Preparing for Incident Command
Hazardous Materials Decontamination
Hazardous Materials Technician
Hazardous Materials Incident Command
Emergency Response to Terrorism: Basic Concepts
Emergency Response to Terrorism: Tactical Considerations - EMS
Emergency Response to Terrorism: Tactical Considerations - Company Officer
Emergency Response to Terrorism: Tactical Considerations - HazMat
Emergency Response to Terrorism: Incident Management

FIRE OFFICER

Advanced Firestreams
Building Construction - Wood and Ordinary Construction
Building Construction - Non-Combustible Construction
Conducting Basic Fire Inspections
Chief Fire Officer Management Training Program
Critical Incident Stress
Executive Skills Series - Managing and Leading a Diverse Workforce
Executive Skills Series - Influencing
Executive Skills Series - Managing and Leading Change
Fireground Company Operations
Flammable Gas Incident Command
Fire Officer I Skills Development

Fire Officer - Mid Level Management
Firefighter Health & Safety
Firefighter Safety & Survival
Incident Command System
Incident Safety Officer
Infection Control - The Supervisor's Role
Instructor Methodology I
Instructor Methodology II
Leadership I
Leadership II
Leadership III
Managing Company Tactical Operations - Preparation
Managing Company Tactical Operations - Decision Making
Managing Company Tactical Operations - Tactics
Public Fire Education Planning
Public Fire & Life Safety Education
Volunteer Fire Service Management
Wildland Interface Firefighting for the Structural Company Officer

RESCUE

Basic Water Rescue
Confined Space Rescue
Confined Space/Trench Rescue Awareness
Ice Rescue
Protective Breathing
Search and Rescue
Basic Rope Rescue
Search and Rescue
Vehicle Extrication

Appendix XI

Mock Booklet Chapter

Floor Systems ...

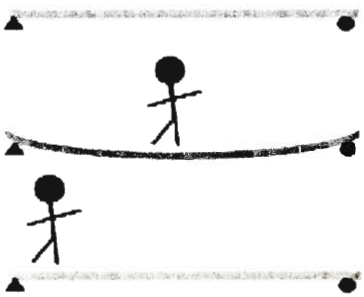
The Need for a Floor System:

General Floor System:

The weight applied to the floor must be counter reacted by the floor supports.

***The force down must be equal to the force up.

Stress:



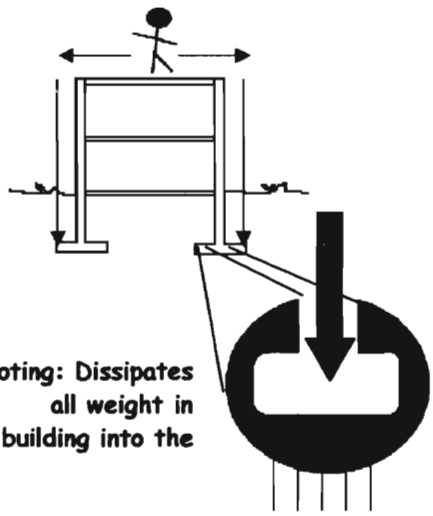
No load on floor → No Stress

Weight in middle of span → Maximum Stress

Weight near supports → Minimal Stress

***Conclusion: It is Safer to walk near the known supports of the floor such as Walls or columns. (Outer perimeter of rooms)

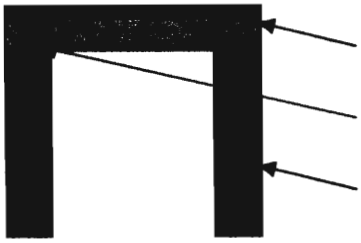
Translation of Forces (General Building):



The force (weight) that a person exerts on a structure is first translated horizontally through the floor system. Then is translated vertically through the wall system. And finally is dissipated into the ground.

The Parts of a floor System:

Cross Section (General Building):



Floor Covering – Aesthetics, not considered to be a structural element

Decking – Carry weight horizontally to distribute to supports

Supports – All weight from decking is distributed among the supports. The Supports carry the weight horizontally to a column or wall.

Connect each piece together

Floor Covering:

***Visible part of the floor. For aesthetic purposes only. Not considered to be structural.

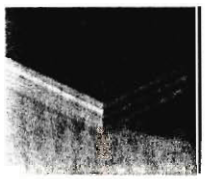
- Carpet
- Tile
- Hardwood
- Linoleum
- Vinyl
- Composite

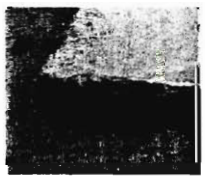
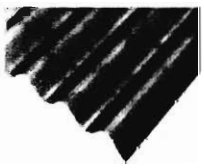



*** Even though most materials shown above are combustible, they do not generally combust due to their location. (So close to the floor)

Decking:

***Under floor surface. Decking is present to carry all loads horizontally to the supports.



Different types of decking depend on materials of construction and the loading to support.

Decking:

Types of Floor Decks:

Steel: *Used in Long Span Construction

Example Picture of Steel Decking

Put down as a platform during construction with poured concrete on top. Steel serves as reinforcement to the concrete.

Steel Decking comes in different forms:

- Corrugated sheets
- Cellular forms (allows for the concealing and running of electrical lines, floor outlets, and plumbing)
- Pan forms

Clues to a Steal Decked Structure: Modern, post 1900's steel construction.
Classic Examples: Sky Scrapers, Large Buildings, Concrete Floors, Heavy Concentrated Loads

Fire Dangers Associated with Steel Decking:

- When Steel is heated it becomes very pliable, pliability greatly reduces the carrying capacity of the steel decking.
- If the integrity of the Steel Decking is weakened, the floor system may become compromised. Concrete is very poor building material when used alone.
- Hidden Dangers: Cellular Decking may be concealing Electric and Plumbing line

Decking:

Types of Floor Decks:

Wood: *Used in Short Span Construction

Example Picture of Wood Decking

Wood decking, or underlayment as it is called, provides a smooth surface for direct application of carpeting or other types of flooring.

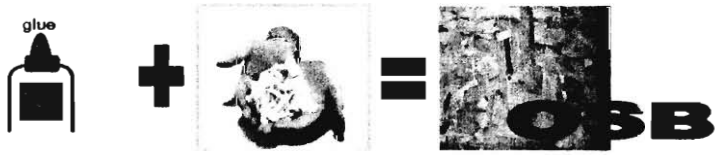
Wood Decking comes in different forms:

- Plywood
- OSB (Chip Board)
- Particle Board

Wood Material: Plywood & OSB

Plywood and OSB can both be used in the form of wooden decking. Both Plywood and OSB are comprised of wood and a glue bonding agent.

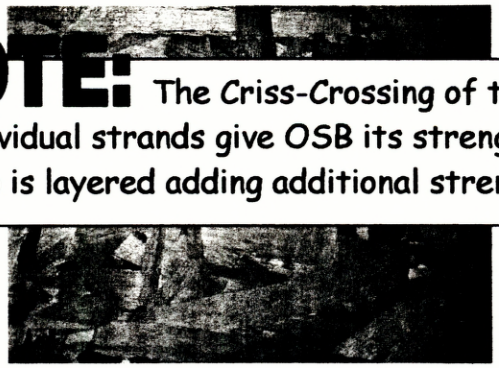
Plywood: Comprised out of several thin sheets of wood glued together under high heat.



- Woodchips (uniform thickness)
- Glue (bonded to wood using HEAT and PRESSURE)

OSB: (Oriented Strand Board) Comprised out of wood chips (hence the name chipboard) aligned in a crisscrossing manor and glued together under high heat and pressure.

Decking:



NOTE: The Criss-Crossing of the individual strands give OSB its strength. OSB also is layered adding additional strength.

Clues to a Wood Decked Structure: Roughly any Residential or Small Commercial Buildings

Classic Examples: Houses, Apartments, Mom and pop's Stores

Fire Dangers Associated with Wood Decking:

- Wood is Flammable and can create noxious gasses when Pressure Treated. Glue used may also release noxious gas.
- Since Plywood and OSB are bonded together with the use of heat, heat will also cause the separation of the materials.
- The separation in the case of a fire can cause rupture and lack of structural stability

Types of Floor Decks:

Reinforced Concrete: *Used in Medium Span Construction

Example Picture of Concrete Decking

Concrete can be used as a form of decking by either pouring it directly onto steel decking or as a pre cast reinforced slab.

Decking:

Pre cast slab poured into wooden form and allowed to cure

NOTE **Slabs have a 2 to 3 hour fire safety rating making them extremely safe**

Clues to a Concrete Decked Structure: Larger Commercial and Industrial buildings dealing with Large Concentrated Laods.
Classic Examples: Office Buildings, Sky Scrapers, Warehouses, Hotels, Hospitals

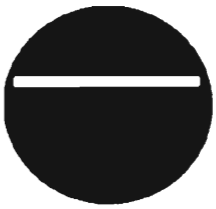
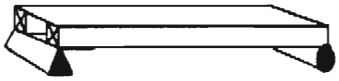
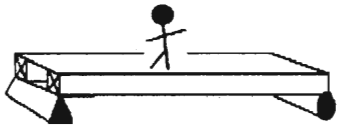
Fire Dangers Associated with Concrete Decking:

- Remarkably safe building material due to fire rating (2 - 3 hrs.)
- Can only become unstable if reinforcing steel or underlying steel deck has been compromised.

Supports:

***All weight from decking is distributed among the supports. The Supports carry the weight horizontally to a column or wall.

The Purpose of Supports (General Building):

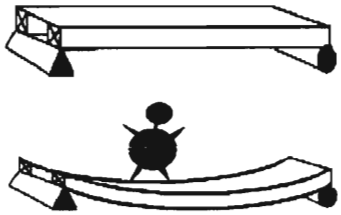
Cross Section	Frontal View	Method of Construction
		Plywood
		Plywood and Weight Applied **********Deforms
		Plywood with Two 4x4 Beams
		Plywood with Two 4x4 Beams and Weight Applied **********Does NOT Deform

WHY?

- The addition of the Beams has added more depth to the span. With the increased depth the span can now hold more weight before it will Deform

Supports:

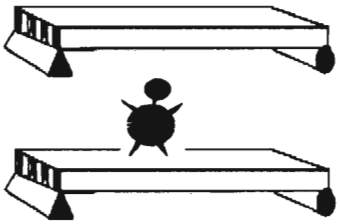
Cross Section **Frontal View** **Method of Construction**



Plywood with Two 4x4 Beams

Plywood with Two 4x4 Beams & More Weight

**********Deforms



Plywood with Four 2x6 Beams (Joists)

Plywood with Four 2x6 Beams (Joists) & More Weight ****Does NOT Deform

WHY?

- The adding of multiple thinner but taller beams (called Joists when used this way) keeps the span from deforming. Even though it is roughly the same amount of materials used, they are used more efficiently and can greatly increase the carrying capacity.
- CONCLUSION:
    - More Spans = Higher carrying capacity
    - Taller Spans = Higher carrying capacity

Supports:

Supporting the Floor System:

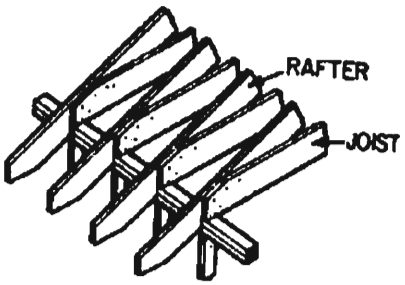
The decking and actual flooring of the floor system will eventually need to be supported some how.

Underneath the decking a series of elements holds the decking up resisting any weight or forces applied upon the floor.

Series of Elements:

Beam: Horizontal element of the floor system. Translates downward force from decking horizontally across the structure.

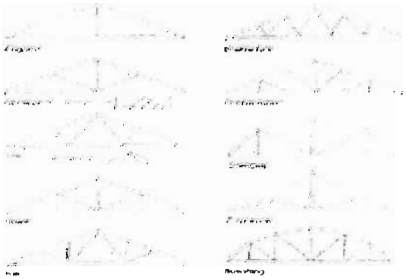
Joist: Similar to the beam's job, but placed in repetition to use smaller dimensions of material, and increase load carrying capacity, also decreases the chance of collapse (If one fails, the others will "pick up the slack").



Rafter: Similar to the beam and Joist's job but used for supporting roofs and are generally sloped.

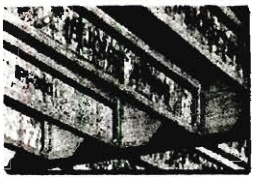
Girder: A girder does relatively the same job as a beam, joist, or rafter, but instead of holding up the decking it holds up the beam, joist, or rafter.

Truss: A hollow version of the beam and joist only containing the needed parts to translate loads (Top Plate, Bottom Plate, and the occasional middle connecting parts). Generally less safe due to the reduction of material.



Supports:

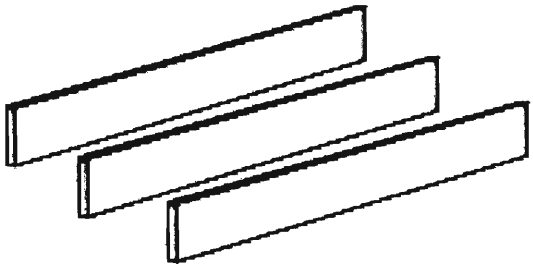
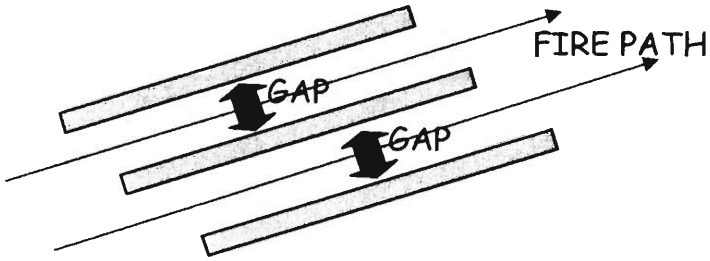
Similar to decking, the support systems are also comprised of different materials:




NOTE: Joists are spaced closer then beams.

Fire Stopping:

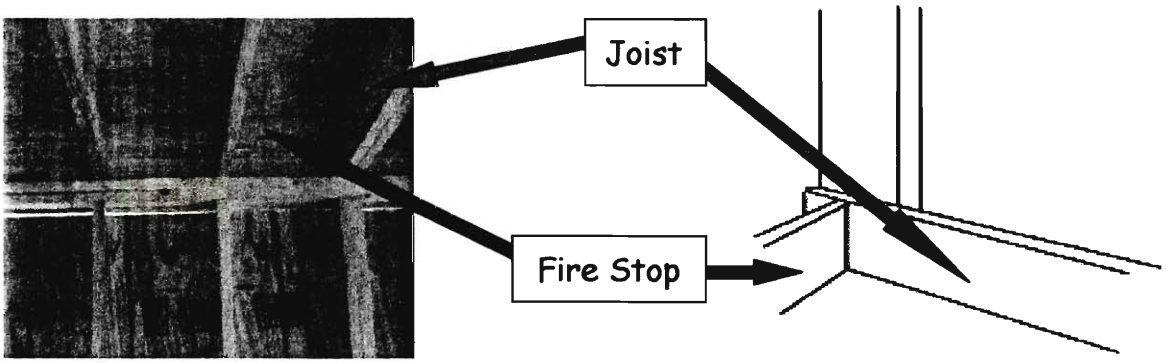
Fire stopping is needed especially in the floor systems containing joists. There are many spaces that can aid the spread of fire.

Joists

The danger of these spaces: A fire that is in one room may have the potential to travel an adjacent room through these spaces found in the floors.

To prevent and retard the spread of fire from room to room, fire stops are added between the spaces of the floor support system.



Types...

Example Pictures of Connections

Example Pictures of Connections

Example Pictures of Connections

Problems with Connections during a Fire:

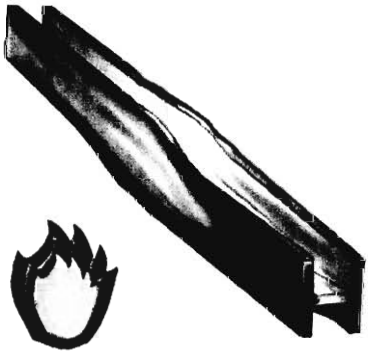
Most connections in buildings are generally made from steel. Steel in very susceptible to high-heat damage and during a fire can radically deform causing instabilities. Connections can separate, melt, or "peal off"

Peeling Off

Materials and Fire:

***What type and how they act under High Heat

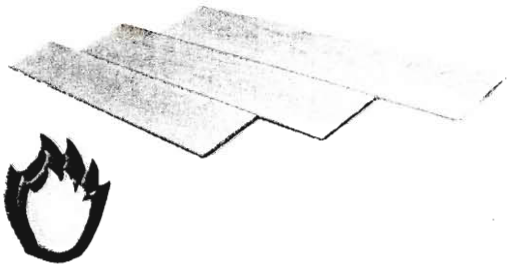
Fire and Steel:



NOTE: Steel may appear to be fire proof but under extreme heat for long periods of time it can deform causing catastrophic failure.

Prevention of Deformation:
Fire proofing may be applied to the steel but it does not actually protect the steel indefinitely, it rather buys some time before the inevitable deformation process.

Fire and Wood:



Everybody knows that wood is the most combustible of the structural building materials. As wood burns the burned portion stays intact on the wood. This is called charring. Charring actually can protect the wood from further fire damage being as it is not combustible once burned. This slows down the burning process.

Materials and Fire:

The Larger the support...The more charring...The longer it can withstand collapse.

Wood Burning Longevity Scale:
Oak → Maple → Cedar → Pine

WHY?

Oak lasts much longer then Pine because of its density. There is more "fuel" found in an Oak beam than a Pine beam. The beam may then burn for a longer time allowing more time for extinguishment of the structure. However due to the density of the wood the fire will burn much hotter with higher flames.

Fire and Concrete:

Concrete is exceptionally safe due to its non-combustibility and high fire rating of at least 2 to 3 hours. However, the steel used in the reinforcing of the concrete is highly susceptible to heat damage. High heat can cause deformation and lead to the cracking and later the collapse of concrete.

Appendix XII

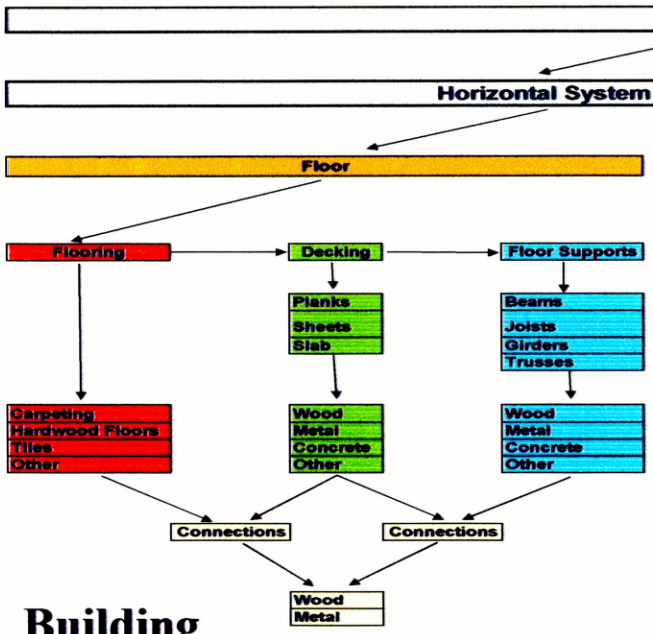
Table of Contents – Building Construction for the Fire Service

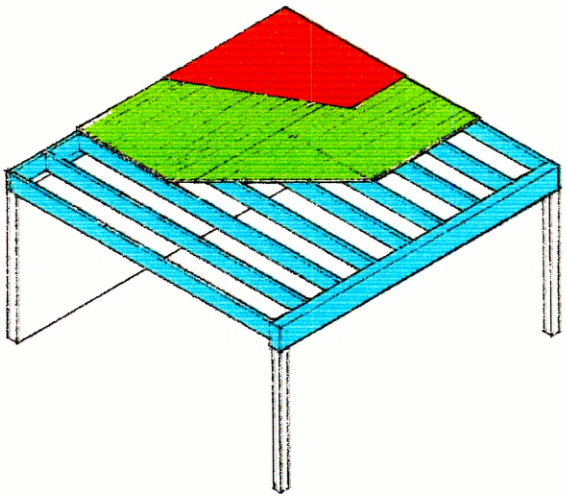
Building Construction for the Fire Service
By
Frank Brannigan

Table of Contents

Appendix XIII

Use of Organization Tree to Classify Structure





Building

↓

Horizontal System

↓

Floor

↓

Flooring

Vinyl Flooring 1/8" Thick

↓

Connections

Glue

↓

Decking

Sheets of Plywood Decking

↓

Connections

10d common nails

↓

Floor Supports

Wooden Joists and girder construction

As progressing down the tree one can neatly organize any structural component. For example when given a particular floor system it is possible to classify it with four elements: Flooring, Decking, Supports, and Connections.

To the left is the classification of the above floor system. Everything is neatly color coded for ease of classification.

Comments: