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Bridging The Pre-Movement and Movement Data Gap Through None FPE Studies

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Objective

Look for data in other disciplines and build on them in regards to pre-movement and movement speeds of humans.

Outline

- Current situation and data gaps
- Examples of available data from other disciplines:
  - Civil Engineering
  - Traffic Studies
  - Medical Studies
- Pathfinder comparative analysis (Non-FPE studies vs. FPE data)
- Future Areas of Improvement

Current Situation

- SFPE & NFPA handbooks assumes homogeneous.
- Pre-movement and movement studies done on some disabled people.
- Pre-movement examples in NFPA handbook gives examples for hotels and office buildings.

Table 3-12.4 *Speed on a Horizontal Surface*

Subject Group (number)	Mean (m/s)	Standard Deviation (m/s)	Range (m/s)	Interquartile Range (m/s)
All disabled (n = 107)	1.00	0.42	0.10–1.77	0.71–1.28
With locomotion disability (n = 101)	0.80	0.37	0.10–1.68	0.57–1.02
No aid (n = 52)	0.95	0.32	0.24–1.68	0.70–1.02
Crutches (n = 6)	0.94	0.30	0.63–1.35	0.67–1.24
Walking stick (n = 33)	0.81	0.38	0.26–1.60	0.49–1.08
Walking frame or rollator (n = 10)	0.57	0.29	0.10–1.02	0.34–0.83
Without locomotion disability (n = 6)	1.25	0.32	0.82–1.77	1.05–1.34
Electric wheelchair (n = 2)	0.89	—	0.85–0.93	—
Manual wheelchair (n = 12)	0.69	0.35	0.13–1.35	0.38–0.94
Assisted manual wheelchair (n = 16)	1.30	0.34	0.84–1.98	1.02–1.59
Assisted ambulant (n = 18)	0.78	0.34	0.21–1.40	0.58–0.92

Table 3-12.5 *Speed on Stairs*

Subject Group (number)	Mean (m/s)	Standard Deviation (m/s)	Range (m/s)	Interquartile Range (m/s)
Ascent				
With locomotion disability (n = 30)	0.38	0.14	0.13–0.62	0.26–0.52
No aid (n = 19)	0.43	0.13	0.14–0.62	0.35–0.55
Crutches (n = 1)	0.22	—	0.13–0.31	0.26–0.45
Walking stick (n = 9)	0.35	0.11	0.18–0.49	—
Rollator (n = 1)	0.14	—	—	—
Without disability (n = 8)	0.70	0.24	0.55–0.82	0.55–0.78
Descent				
With locomotion disability (n = 30)	0.33	0.16	0.11–0.70	0.22–0.45
No aid (n = 19)	0.36	0.14	0.13–0.70	0.20–0.47
Crutches (n = 1)	0.22	—	—	—
Walking stick (n = 9)	0.32	0.12	0.11–0.49	0.24–0.46
Rollator (n = 1)	0.16	—	—	—
Without disability (n = 8)	0.70	0.26	0.45–1.10	0.53–0.90

Current Situation and Data Gaps[1]

- In reality, people are **heterogeneous** (normal and disabled people together)
- **Lack of data** in pre-movement and movement
- **Data very old** and constantly changing & evolving. Example: Fruin 1971
- Focus on how the data was obtained and the quality of the data.
- Several factors to take into consideration:

Human related

- Health
- Size and weight
- Culture effects

Building & Environment related

- Geometry effects
- Design of egress path
- Weather

Non-FPE Disciplines

Civil Engineering

Traffic Engineering

Medical

Civil Engineering Stu

Civil Engineering Study (ASCE) by USU[2]

- They studied the behavior of vulnerable populations in various built environments.
- Analyzed walking speeds and difference between homogeneous & heterogeneous crov
- They built a circuit in a 3,000 ft^2. 202 people (180 without disability, 22 with)
- Used existing staircase. 100 people tested (8(without disability, 20 with, no wheelchair)
- Used actual disabled percentage data: 2.1% visual, 6.8% ambulatory.
- Used automated video identification and tracking (can identify 512 at once)

Table

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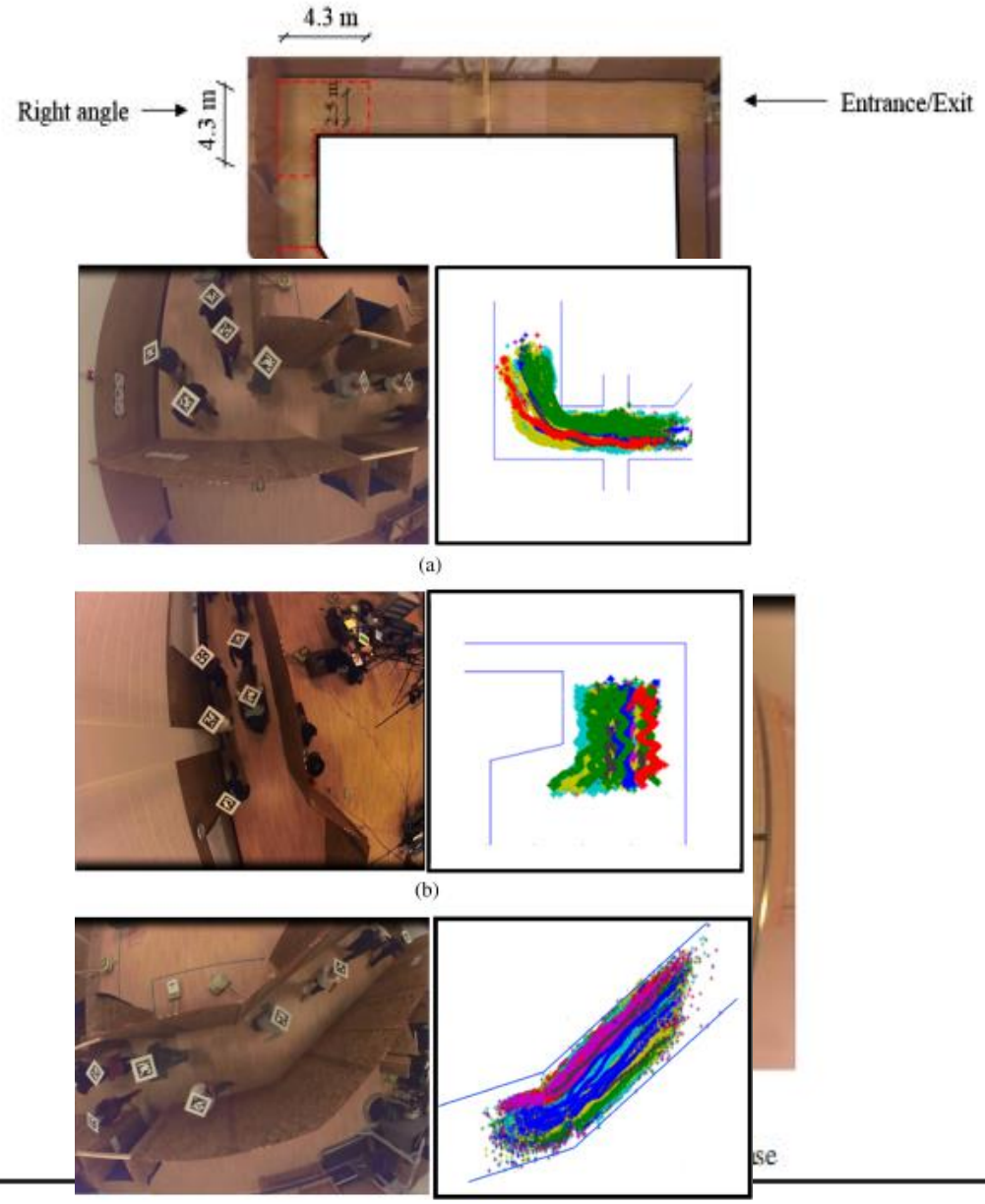


Civil Engineering Study[2] (Cont.)

Civil Engineering Study (ASCE) by USU

- Significant reduction of the mean speed of heterogeneous population in all types of walking facilities.
- Benefits to FPE:
  - Mean speeds for: Disabled (visual & mobility), Geometry, Age (18-64)

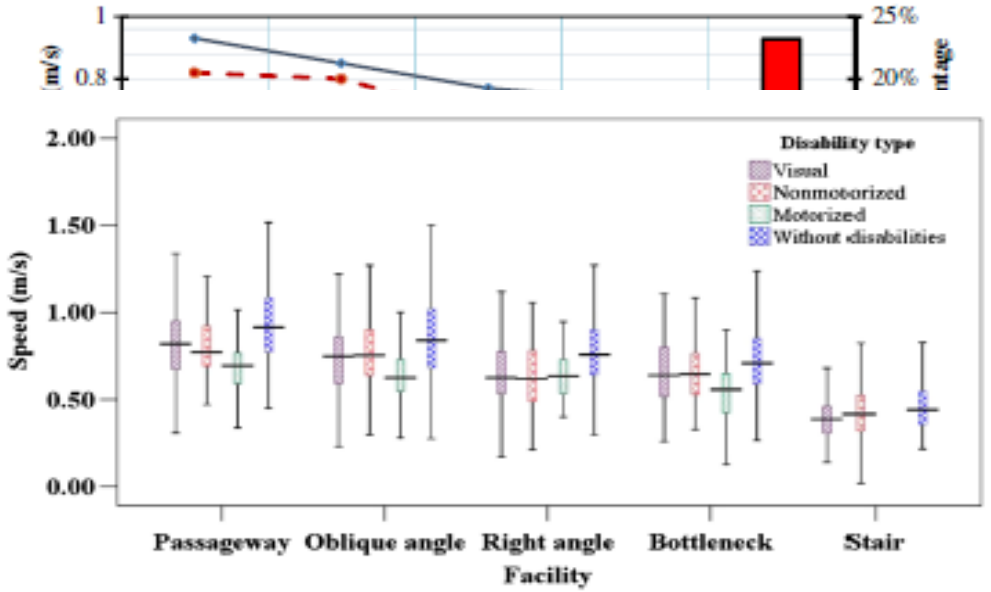


Fig. 5. Walking speed statistics for different pedestrian groups and walking environments

Civil Engineering Study[3]

Civil Engineering, University College of London, UK

Study on Walking Speeds of Pedestrians on Stairs

- Elderly: n = 18, no disabilities. Young: n = 15
- Compared mean walking speed with data from Fruin. Fruin result was slower.
- Difference may be due to:
  - Individual laboratory results vs. actual facilities.
  - Effect from other people
- Benefits to FPE:
  - Age difference
  - Culture Difference
  - Stair Speed

Table 6. Comparison between our results and Fruin (1971)

	Stair gradient	Ascending				Descending			
		Elderly		Young		Elderly		Young	
		Male	Female	Male	Female	Male	Female	Male	Female
This study	38.8	0.41	0.46	0.50	0.47	0.46	0.48	0.61	0.57
	35.0	0.50	0.53	0.57	0.56	0.60	0.57	0.62	0.67
	30.5	0.56	0.60	0.65	0.62	0.64	0.64	0.72	0.76
	24.6	0.68	0.76	0.77	0.75	0.80	0.80	0.82	0.91
Fruin (1971)	32	0.43	0.39	0.69	0.51	0.57	0.47	0.69	0.51
	27	0.41	0.45	0.81	0.65	0.60	0.56	0.81	0.65

Horizontal walking speeds (m/s)
(Stair-gradient: (degree))
Data of Fruin: Data of pedestrians aged more than 50 is applied into "Elderly"
Data of pedestrians aged from 30 to 50 is applied into "Young"

Civil Engineering Study[4]

Civil Engineering, Technical University of Denmark

Visual Impairment Study

- n = 57, age: 10-79
- Multiple tests: single and group evacuations.
- Experiments done in: Denmark & USA, then compared to SFPE (Nelson & Mowrer, N&M)
- Benefits to FPE:
  - Culture Difference
  - Visual Impairment

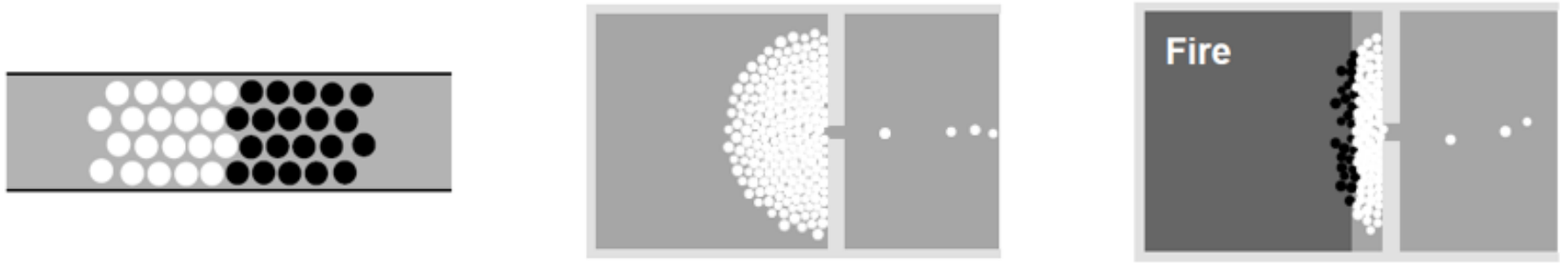
Findings – Building Design

- Lightning conditions
  - People with low vision benefit from a well lighted emergency path. This is not only beneficial for people with low vision, but also for people without visual impairments.
- Handrail
  - Continuing handrails also on landings
  - Awareness marking at start and end
- Differences in surface texture and color
  - Blind and people with low vision use their sense of feeling while they orientate in a building.
  - Different textures on e.g. wall and emergency exit would help to identify the exit.
  - Color differences could be beneficial for people with low vision to recognize exits.

Traffic Engineering Study[5]

Traffic Engineering, and Biological Physics

- Studied people movement in normal and evacuation situations
- Related pedestrian movement to fluid dynamics and developed a theoretical microscopic simulation of pedestrian streams
- Developed force models suitable for drawing conclusions about the possible mechanics beyond escape panic.



(A) Freezing by heating (B) transition into coordination due to clogging (C) faster is a slower effect

Medical Science Study[6]

Medical Studies, Australia

- Gait speed: type of movement people engage in to get from one point to another.
  - Time over 15 m.
  - Reported as a continuous measure.
  - Measured straight walk
  - Uniform conditions.
- From 4646 studies, 48 chosen: n = 7000
- Age: 70+, hospital inpatient and outpatient
- Usual pace: 0.58 m/s, max pace: 0.89 m/s
- Females 63%
- In Acute care: Usual pace: 0.46 m/s
- Outpatient: usual pace: 0.74 m/s
- Compare to normal in community dwelling:
  - Age 70-79: Females=1.13 m/s, Men=1.26m/s
  - Age 80-99: Females=0.94 m/s, Men=0.97 m/s
- Benefits to FPE:
  - Hospital
  - Age
  - Males and Females

Medical Science Study[7]

University of Madrid, Department of Health and Human Performance

Study of Reaction Time (RT) to Visual Stimuli in Athletes with & without a Hearing Impairment

- Athletes without hearing impairment: n = 79, mean age = 22.6 year, SD =3.7
- Athletes with hearing impairment: n = 44, mean age = 25.6 years, SD = 5.0
- Conclusion:
  - RT for athletes with hearing impairment was significantly shorter.
  - Also, shorter RT for males
  - No difference regarding type of sport.
- Benefits to FPE:
  - Pre-movement time
  - Hearing impairment people data
  - Male & female difference

Pathfinder Comparative Analysis

Building Description:

- 13 story office building.

- 4200 capacity.

Input data used:

- USU Civil Eng. Study:

Mean Speed	**0.93 m/s**
Min. Speed	0.71 m/s
Max Speed	1.15 m/s
Standard Deviation	0.22 m/s

-SFPE HB 5th Edition Data:

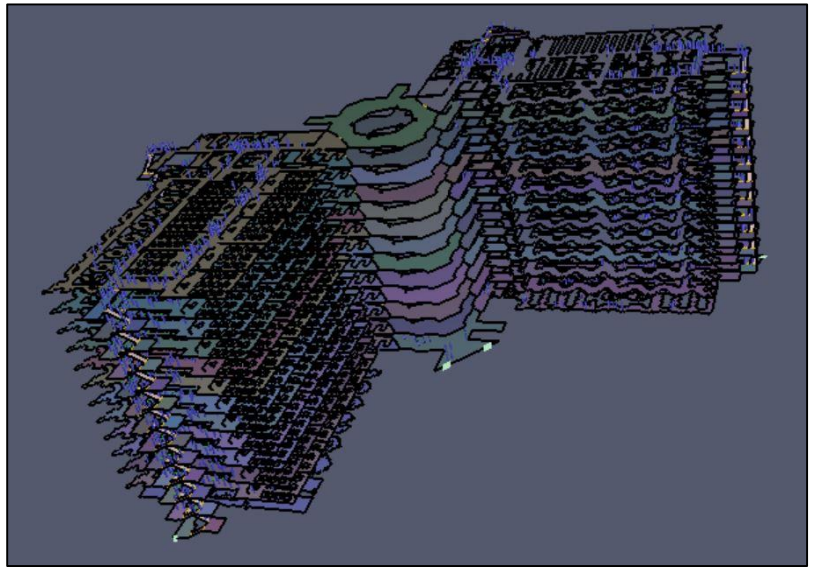
Min. Speed	**0.31 m/s**
Max Speed	1.4 m/s

Pathfinder Comparative Analysis

Observations:

- SFPE Evacuation time: 2081s

- Non-FPE Evacuation time: 1691s (Closer to actual)



Factors affected the results:

- Uniform vs. normal walking speeds.

- Methods used to collect the data.

- Quality of both data, location, and culture.

It is important to conduct more detailed analysis to determine the independent variable with significant effects

Conclusion & Future Areas of Improvement

- Each designer shall build up his own database suitable for the location he is designing for.
- FPE's need to work with other disciplines, learn from them, in order to get more robust studies.
- Centralize data in FPE, and data reporting should be standardized.
- D. Mileti: "What we study is people and how people respond. It doesn't matter what the hazard agent is. The same kinds of questions and theories apply, whether it's terrorism, or an earthquake, or flooding or a dam failure."[9]

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