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Seismic Safety Standards of Private School Buildings in the San Francisco Bay Area: An Exploratory Study

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<u>Seismic Safety Standards of Private School Buildings in the San Francisco Bay Area:</u>

<u>An Exploratory Study</u>

by

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TABLE OF CONTENTS

INTRODUCTION

Research Question

The purpose of this study is to examine whether the Private Schools Building Safety Act of 1986 had an impact on the seismic safety of private school buildings in the San Francisco Bay Area. The Private Schools Building Safety Act was inspired by the Field Act of 1933 and subsequent legislation that significantly improved the seismic safety of California's public schools. This paper begins by describing seismic activity characteristic of California and proceeds to elaborate upon legislation pertaining to the design and construction of school buildings. Following that is a description of the methods used to investigate the impact of the Private Schools Building Safety Act, the results of the study, and an analysis of the collected data.

Earthquakes in California

Earthquakes are inevitable in California. The state straddles the Pacific Plate and the North American Plate which move against each other at a rate of approximately 1.5 inches per year, or 18 inches per decade (United States Geological Survey, n.d.). The San Andreas fault, perhaps the most well-known collection of faults among the general population, represents the meeting of these two plates. California contains approximately 200 faults that are considered potentially active based on geological activity over the last 10,000 years. Hundreds of other faults have been identified, but appear to be harmless based on recent geological history (California Department of Conservation, 2019).

More than 70% of California's population lives within 30 miles of a fault that could cause substantial ground shaking within the next 50 years. Each year, California experiences two to three earthquakes of Richter Magnitude 5.5 or higher, powerful enough to cause at least moderate damage to buildings (California Department of Conservation, 2019). In a 2004 report, the California Seismic Safety Commission demonstrated that earthquakes can cause substantial structural damage to buildings and infrastructure with poor structural integrity, which may cost billions of dollars to repair. While major earthquakes have been recorded since the early 19th century, construction standards were not mandated by the state until 1933 (California Seismic Safety Commission, 2004).

Legislation Regulating Public School Buildings

The Field Act of 1933 was the first major piece of legislation governing the construction of new buildings in California's public schools (Liel, 2012). It was enacted in response to the Long Beach earthquake in which, just one month prior, 300 schools endured minor damage, 120 schools received major damage, and 70 schools were utterly destroyed (Dwelley-Samant, 2013; Goldstein, 2019). The Field Act grants the Division of the State Architect under the Department of General Services the authority to establish administrative requirements regarding the design, approval, and inspection of new buildings as well as structural requirements that would reduce the risk of collapse (California Seismic Safety Commission, 2020). Specific regulations are outlined in the California Building Standards Code, which is updated and referenced every three years (California Seismic Safety Commission; 2004).

While the Field Act helped to mitigate earthquake damage in all new public school buildings, it did not address safety concerns for buildings constructed before 1933. The Garrison Act of 1939 increased the authority of the State Architect and applied existing building standards to pre-1933 public school buildings (Alquist, 2009; Liel, 2012). Buildings constructed before the enactment of the Field Act were to be inspected by local school districts, and, if deemed unsafe by current building regulations, to be retrofitted or abandoned. The Garrison Act did not specify a deadline for the inspections, however, and cities which had not previously experienced high-magnitude earthquakes often delayed the process. In 1967 and 1968, the California legislature enacted the Greene Acts, which mandated that structural evaluations for all public school buildings constructed before 1933 must be submitted by 1970, and that unsafe buildings must be prohibited for student use by 1975 (Alquist, 2009; Dwelley-Samant, 2013; California Seismic Safety Commission, 2002).

The Uniform Building Code was amended in 1976 to improve the seismic design of buildings, and in 1978 the changes were incorporated into the design and construction of public school buildings (Liel, 2012). In 1999, California Legislature passed Assembly Bill 300, which "required the Department of General Services to conduct an inventory of kindergarten - 12th grade public school buildings that featured concrete tilt-up construction and non-wood frame walls that do not meet the minimum requirements of the 1976 Uniform Building Code" (Castellanos, 2003). The Department of General Services was further required to submit a report summarizing their findings to the Governor and the California Legislature. Before conducting the inventory, the Division of the State Architect determined that, of the 60,000 public school buildings being used in California at the time, only approximately 16,000 buildings warranted evaluation based on the criteria established in AB 300. Of those 16,000, 7,537 buildings (~14% of all public school buildings in California) did not satisfy the structural requirements established in the 1976 Uniform Building Code and required further evaluation. The inventory determined that an additional 2,122 buildings (~6% of all public school buildings in California) were likely to perform well in future earthquakes despite having non-wood frames (Castellanos, 2003; Dwelley-Samant, 2013; California Seismic Safety Commission, 2002). The State recommended that cities and counties perform detailed structural evaluations of the schools on the AB 300 list, but as of 2013 the State had neither required school districts to do so nor provided funding for it (Dwelley-Samant, 2013).

While no single source documents the response of all cities and counties to the AB 300 list, the City and County of San Francisco serves as an interesting example. 72 of the public school buildings on the AB 300 list were located within the San Francisco Unified School District, and in the following years the district secured funding to perform independent evaluations of 86% of buildings on the list (Dwelley-Samant, 2013). The findings are included in Table 1 below.

Table 1

Status of San Francisco Public School Buildings on the AB 300 List as of 2013

Status of San Francisco Public School Buildings on AB 300 List of Schools That May Have Seismic Safety Concerns	**Number of Buildings**
Structural upgrades completed	25
First phase upgrades complete, second phase planned	1
Evaluated, no upgrade needed	4
Evaluated, upgrades planned	15
Evaluated, upgrades needed, not yet funded	3
In assessment phase, minor upgrades needed	2
Used for non-school administration	3
Not in use	2
Demolished	2
Sold	5
Not yet evaluated, not yet funded	10
Total	**72**

Source: San Francisco, 2013.

The findings shown in Table 1 demonstrate the limited effectiveness of the AB 300 list. While 30 of the buildings had either been upgraded, begun upgrades, or determined that upgrades were not required, an additional 20 buildings had still not begun upgrades a decade after the list was published. The findings further indicate that no one agency was aware that 9 of the buildings on the AB 300 list were demolished, sold, or not being used. The fact that the seismic safety of 10 buildings had yet to be evaluated and funded, nearly 14% of the buildings the AB 300 list identified in San Francisco, further illustrates the challenges school districts face when determining how to assess the safety of public school buildings. It should be noted, however, that when San Francisco's non-AB 300 buildings are taken into consideration, 88% of buildings were expected to perform well during an earthquake as of 2013, and 12% had characteristics that made them more vulnerable to seismic damage (Dwelley-Samant, 2013). These figures are substantially better than those for private school buildings, as shown in the following section.

Legislation Regulating Private School Buildings

While public schools shifted their construction policies for new buildings, evaluated the safety of existing buildings, and retrofitted as needed, private schools were exempt from such regulations until the Private Schools Building Safety Act (PSBSA) of 1986 was added to the California Education Code (Dwelley-Samant, 2013; Kraatz, 2009). The PSBSA acknowledges the disparities in construction standards between public and private schools in section 17321, stating, "[n]ot all students of private schools enjoy the same or equivalent earthquake safety as is afforded to students of public schools by the Field Act and other legislation," and, "[m]odifications of building design, plan checking, and inspection procedures can offer increased protection to private school students." The PSBSA further states in section 17322 that, "it is the intent of the Legislature that children attending private schools be afforded life safety protection similar to that of children attending public schools" by ensuring that private school buildings are designed and constructed to resist "the forces generated by earthquakes, gravity, and winds to the extent necessary to ensure the safety of occupants." The remainder of the PSBSA outlines construction, design, and inspection procedures (Private Schools Building Safety Act, 1986).

Unlike the Field Act, which gives the Division of the State Architect the authority to craft and enforce specific regulations pertaining to the design, construction, and inspection of public school buildings, the PSBSA leaves all the power to the applicable “enforcement agency,” defined in section 17323 as the “agency of a city, city and county, or county responsible for building safety within its jurisdiction” (Private Schools Building Safety Act, 1986). Because cities and counties across the state have differing design, construction, and administrative standards, the private schools within their jurisdiction will have differing levels of earthquake resistance. Regardless of any inconsistencies between enforcement agencies, the PSBSA, if followed correctly, should ensure a certain degree of safety for occupants of private school buildings during an earthquake (Dwelley-Samant, 2013). Possible exceptions include buildings included in section 17325, which states that, “[p]rivate school structures of one-story Type V [wood-framed] and Type II-N [unprotected non-combustible] construction, as defined by the Uniform Building Code, that are 2,000 square feet or less in floor area are exempt from the provisions of this article” (Private Schools Building Safety Act, 1986; Huntington et al., 1989).

While no single source documents the extent to which cities and counties have evaluated the seismic safety of their private school buildings, the City and County of San Francisco again serves as an interesting example. In the same report that evaluated the seismic safety of San Francisco’s public school buildings, investigators mirrored the criteria established for the AB 300 evaluations to identify private school buildings that might not perform well during large earthquakes (Dwelley-Samant, 2013). Of the approximately 218 private school buildings found in San Francisco, 94 buildings (43.1%) had structural characteristics that indicated that they were likely to perform well during future earthquakes, 72 (33.0%) had structural characteristics that indicated they might perform poorly in future earthquakes, and investigators were unable to obtain sufficient information for 52 buildings (23.9%) to make a determination. It should be noted that the percentage of vulnerable school buildings in San Francisco is not a strong indicator of the percentage of students that occupy vulnerable buildings. Investigators from San Francisco's Earthquake Safety Implementation Program (2013) pointed out several factors that prevent such an extrapolation:

> [The 113 private schools in San Francisco] vary tremendously in number of students… Some are large schools that own sprawling campuses and serve more than one thousand students. Others serve fewer than ten students in rented space… An estimated 26 of the schools serve 50 or fewer students; an estimated 16 schools serve 25 or fewer students. Some have over a hundred years of history, while others are brand new to San Francisco. It appears that new schools open and other schools close on a regular basis, so the exact number and names of private schools in San Francisco vary each year. (p. 21)

Not only are a greater percentage of private school buildings seismically unsafe compared to their public school counterparts, but the City and County of San Francisco's ability to track the structural integrity of private school buildings is hampered by the fact that the very number of schools fluctuates on an annual basis (Dwelley-Samant, 2013).

Legislation Regulating Charter School Buildings

Although charter schools are public educational institutions, they are not automatically subject to the Field Act. However, if a charter school operates on property owned by a public school district, chooses to involve the Division of the State Architect or other state agencies for project approvals, or receives funding under certain government programs such as the Charter Schools Facilities Program, they must adhere to the same construction standards as traditional public schools (Kollman & Forest, 2018). According to the Legislative Analyst's Office (2006), no major charter school legislation has explicitly clarified which seismic safety standards charter schools must follow when they are not subject to the Field Act. The Seismic Safety Commission further reported that:

> Which building regulations apply when the Field Act does not apply, appears to be subject to debate and interpretation. Some building officials during this study stated that some charter schools have argued that they should be exempt from any plan review of the design or inspection of the construction, by either the State Architect or the local building departments. (p. 7)

Charter schools that do not operate on property owned by a school district and do not seek funding from special government programs may elect to conform to the safety standards of the California Building Standards Code as enforced by the city or county in which the school is located (Kollman & Forest, 2018).

LITERATURE REVIEW

Administrative and Structural Regulations for Public School Construction

The Uniform Building Code was California's model building code when the Field Act and PSBSA were enacted (the model code was changed to the International Building Code in 2000) (Kelley, 2013). The Division of the State Architect amended the Uniform Building Code to create Title 24, California Code of Regulations (CCR) governing the construction of public schools. Title 24 establishes administrative requirements beyond those included in the model code and grants the state the authority to enforce the regulations (California Seismic Safety Commission, 2004). For instance, design plans for public schools must be drafted under the responsible charge of an architect or a structural engineer, rather than a municipal civil engineer. An inspector certified by the DSA must be present on site during all stages of construction, whereas the model code only calls for periodic inspections at construction milestones (Dwelley-

Samant, 2013). Title 24 also establishes specific requirements pertaining to plan submissions and reporting requirements which must be completed by the inspectors, architects, engineers, and contractors under penalty of perjury (California Seismic Safety Commission, 2004).

The Seismic Safety Commission (2004) further demonstrated that structural requirements under Title 24 are also more stringent than those established by the model building code. Public school buildings are required to withstand greater forces created by gravity, wind, or earthquakes. Materials used in construction are tested more frequently and more thoroughly than those used in non-Field Act buildings, and some materials allowed by the model building code are not permitted for public school buildings at all (California Seismic Safety Commission, 2004). These strict regulations have rendered public school buildings among the safest structures in the state (Goldstein, 2019). Evidence for the efficacy of the Field Act and subsequent legislation are found in damage assessments of high-magnitude earthquakes such as the El Centro earthquake of 1940, the Imperial Valley earthquake of 1979, the Loma Prieta earthquake of 1989, the Northridge Earthquake of 1994, and the South Napa earthquake of 2014. Although such earthquakes often caused billions of dollars' worth of damage, public school buildings suffered relatively little harm (Dwelley-Samant, 2013).

Administrative and Structural Regulations for Private School Construction

As noted above, private school buildings are not subject to Title 24 of the CCR. The PSBSA grants cities and counties the authority to enforce the model building code and to use their discretion in implementing additional safety criteria (Kraatz, 2009). Under the model building code, civil engineers are permitted to be largely responsible for the design and construction of buildings. Project inspectors are not required to be DSA-certified and they may only visit the construction site after major steps have already been completed. Inspectors, architects, engineers, and contractors are not required to submit reports showing that the project adheres to all plans and specifications. In short, under the model building code, private school construction projects have less oversight, less accountability, and greater opportunities for error (California Seismic Safety Commission, 2004). A more detailed comparison of administrative and structural requirements established in Title 24, CCR, for the construction of public school buildings with the requirements outlined the Uniform Building Code as it pertains to the construction of private school buildings may be found in Appendix A.

As noted above, private school buildings are required to meet the construction standards of the model code, but local enforcement agencies have the authority to implement more stringent requirements if they choose. The City and County of San Francisco, for instance, periodically updates its San Francisco Building Code which, over time, has included improvements to the seismic safety of new buildings. Typically, private buildings are only required to meet the safety standards of the building code at the time of construction. An owner of a private building constructed 100 years ago is only required to satisfy the safety standards of the building code as it was 100 years ago, even if the building is clearly unsafe. Fortunately, there are exceptions to this rule, including requirements to retrofit unreinforced masonry buildings, requirements for schools that undergo substantial renovations, and requirements for schools that have purchased buildings that were not previously used for educational purposes (Dwelley-Samant, 2013). A comparison of construction standards between San Francisco's public and private schools is provided in Appendix B.

Hurdles in Implementation

In a report to the Governor, the California Seismic Safety Commission (2004) argued that, "[the PSBSA] cites the California Building Code, and not the portion of that code governing

Field Act buildings as the standard, resulting in many instances in lower standards" (p. 7). The Commission further argued that the PSBSA, being in the Education Code rather than the Building Code, may be overlooked by builders (California Seismic Safety Commission, 2004).

The decision to place the PSBSA in the California Education Code may have counteracted the authors' intention to provide private school students with "life safety protection similar to that of children attending public schools," as stated in section 17322 of the PSBSA. Private school administrators reviewing the Education Code may be familiar with the PSBSA, but they are likely to be unfamiliar with the provisions outlined in Title 24 of the California Code of Regulations that make public school buildings among the safest buildings in the state. They will not know that the Division of the State Architect mandates stricter design and administration standards for public schools than for private schools, and will not know to request similar levels of prudence from the architects, construction firms, and enforcement agencies. The engineers and construction firms will be familiar with the model building code, but are probably unfamiliar with the California Education Code (California Seismic Safety Commission, 2014).

Secondly, while the PSBSA calls for similar levels of life safety for private school students, it does not legally require engineers, construction firms, or enforcement agencies to actually provide it. The PSBSA mandates due diligence during the design and construction process but leaves it to the schools and enforcement agencies to determine whether they want to provide a level of seismic safety beyond what the model code affords (California Seismic Safety Commission, 2014).

Finally, private school administrators may be tempted to omit non-mandatory safety measures to reduce the costs and the duration of construction. The Field Act increases the cost of construction for new buildings by 3-4%, and while increased safety measures result in savings in the long run because the buildings suffer less structural damage, administrators may be tempted to cut the cost of construction as much as possible (California Seismic Safety Commission, 2004).

METHODOLOGY

Type of Analysis

This research takes the form of a public policy analysis (Sylvia and Sylvia, 2012). There are three primary goals in conducting this evaluation. The first goal is to determine whether private school buildings in the San Francisco Bay Area may be expected to perform well in high-magnitude earthquakes, what percentage of private school buildings may perform poorly, and what percentage of private school buildings lack enough information to make a determination. These determinations were based upon the year in which the buildings were constructed or renovated; if a building was constructed prior to 1986, when the PSBSA was enacted, and has not been renovated since, it is assumed that the building was not constructed according to the Uniform Building Code's current seismic safety standards. If a building was constructed or renovated after 1986, it is assumed that the building can be expected to perform well during an earthquake. If respondents respond that the requested information is unavailable, it is assumed that there is not enough information to make a determination. It should be noted that the purpose of this estimate is to provide an approximation of the seismic safety of private school buildings in the San Francisco Bay Area, rather than a definitive evaluation of them. The seismic safety of any particular building can only be determined through an inspection by a certified structural engineer, and inclusion in this research is not an indication of a building's life-safety overall.

The second goal of this evaluation s to determine whether employees are familiar with the history and condition of school buildings. Many questions in the survey allow the respondents to state that information regarding school construction requested is unknown to them. While such responses will not necessarily affect the estimation of the school's safety, they will indicate that the PSBSA was not effective in educating private school employees about seismic safety standards.

The third goal is to learn which of the following factors are important to school administrators when determining which organization will design and construct new buildings: the estimated cost of construction; the estimated time to complete construction; a personal relationship with an employee of the organization; whether the organization has prior experience in constructing private school buildings; recommendations from peer schools; and heightened safety standards compared to other organizations. Responses determined whether heightened safety measures were preceded, and perhaps prevented, by other values. For instance, if administrators prefer organizations that can complete construction more quickly than their competitors and at a favorable price, the following assumption was that heightened safety standards are not implemented, since they require more time and money to implement.

Data Collection

A Qualtrics survey was sent to the administrators of 699 private schools located within the nine counties of the San Francisco Bay Area (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma). Because the Field Act only applies to public schools teaching kindergarten through 12th grade, only private schools teaching at least three grades within this range were contacted. Contact information for the administrators was obtained from a publicly-available dataset located on the California Department of Education's website.

The survey consisted of a consent form and 15 questions pertaining to each school. The survey was intended to obtain general information pertaining to the size and location of each campus, the year of construction and subsequent renovations of existing buildings, plans for construction of new buildings or renovation of existing buildings, and which factors influence the school's decision when choosing an organization to design and construct new buildings. Because the survey was expected to be completed by school administrators, who can be assumed to be unfamiliar with structural and administrative construction standards, the survey did not solicit information regarding the design, construction, or inspection of school buildings. Responses from returned surveys were aggregated so that no particular school or administrator could be associated with the data. No personally identifiable information about faculty, staff, or students was solicited., thus it was ecluded from Institutional Review Board review.

Collected data was expected to reveal to what extent private school buildings may be trusted to perform well during large earthquakes. Depending on the year of construction, the materials used during construction, and the size of the school, responses were expected to reveal what percentage of private school buildings comply with seismic safety standards established in the Uniform Building Code of 1976. Because the survey did not solicit detailed information regarding the design, construction, and inspection of buildings, however, responses to this survey were not expected to reveal to what extent private school buildings exceed standards established by the model code. In other words, the data would show how effective the PSBSA was in establishing safety standards for private schools, but it could not determine whether "children attending private schools [are] afforded life safety protection similar to that of children attending public schools," as the Act intended (Private Schools Building Safety Act, 1986).

IRB Exclusion

This project meets the exclusion criteria of San Jose State University's I Institutional Review Board's process. Much of the data that was collected, solicited, and analyzed is publicly available and has been published by the California Department of Education or by the schools themselves. When solicited information was not publicly available, such as a school's construction history or plans for renovation, the expectation is that participants only respond insofar as they are representatives of the schools. Since this project is a systematic investigation, is designed to contribute to generalizable knowledge, does not involve human subjects, and does not contain identifiable information, it qualifies for exclusion from an IRB review.

FINDINGS

Participation in the Survey

Of the 699 survey invitations sent via email, 26 were returned as undeliverable, 32 were sent to duplicate emails, and 2 failed to send, resulting in 666 successful distributions to school administrators. Of the 666 administrators successfully contacted, 104 began the survey and 68 completed the survey. The percentage of participation per county is included in Table 2 below.

Table 2

Percentage of Survey Participation per County

County	Administrators Contacted	Administrators Responded	Response Rate
Alameda	137	10	7.30%
Contra Costa	93	8	8.60%
Marin	41	4	9.76%
Napa	16	2	12.50%
San Francisco	100	8	8.00%
San Mateo	76	12	15.79%
Santa Clara	168	19	11.31%
Solano	23	0	0%
Sonoma	45	5	11.11%
Total	**699**	**68**	**9.73%**

Survey responses revealed that participating schools varied greatly in the number of faculty and staff employed, the number of students enrolled, the number of grades taught between kindergarten and 12th grade, and the years in which the schools were founded. Many schools had a comparatively small number of buildings, faculty, students, and grades taught, while others had many buildings, hundreds of staff employed, hundreds of students enrolled, and curriculum for students enrolled in kindergarten - 12th grade. While the nature of participating schools was diverse, it can not be said to be representative of all private schools in the Bay Area as the response rate was relatively low. The data collected and conclusions subsequently drawn therefore constitute an exploratory study of private school buildings, rather than a definitive characterization of them.

Construction and Renovation History of Participating Schools

The second part of the survey asked participants to enter the total number of buildings on campus, the number of buildings known to be built before 1986, the number of buildings known to be built before 1986 and retrofitted after 1986, and buildings known to be built after 1986. Participants were given the opportunity to enter "unsure" if they were unfamiliar with the year of construction or retrofitting. The results of the survey are presented in Table 3 below.

Table 3

Construction History of Private School Buildings by County

County	Total schools	Total Buildings	Pre-1986 Buildings	Post-1986 Buildings	Unknown construction year
Alameda	10	39	17	4	18
Contra Costa	8	21	15	3	3
Marin	4	25	13	12	0
Napa	2	16	15	1	0
San Francisco	8	12	11	1	0
San Mateo	12	75	25	49	1
Santa Clara	19	118	76	42	0
Solano	0	n/a	n/a	n/a	n/a
Sonoma	5	16	7	9	0
Total	**68**	**322**	**179**	**121**	**22**

The dates of construction and subsequent renovation permit an estimation of the number of buildings considered to be seismically safe. It should be noted that, while most administrators knew whether buildings were constructed before or after 1986, most were unsure whether older buildings had been retrofitted. Thus, while Alameda County has one private school building known to be retrofitted since 1986, it is possible that other pre-1986 buildings have been retrofitted unbeknownst to the participant. Table 4 highlights this uncertainty by showing how many pre-1986 buildings are known to have been retrofitted, how many pre-1986 buildings are known to not have been retrofitted, and how many pre-1986 buildings are unknown to have been retrofitted.

Table 4

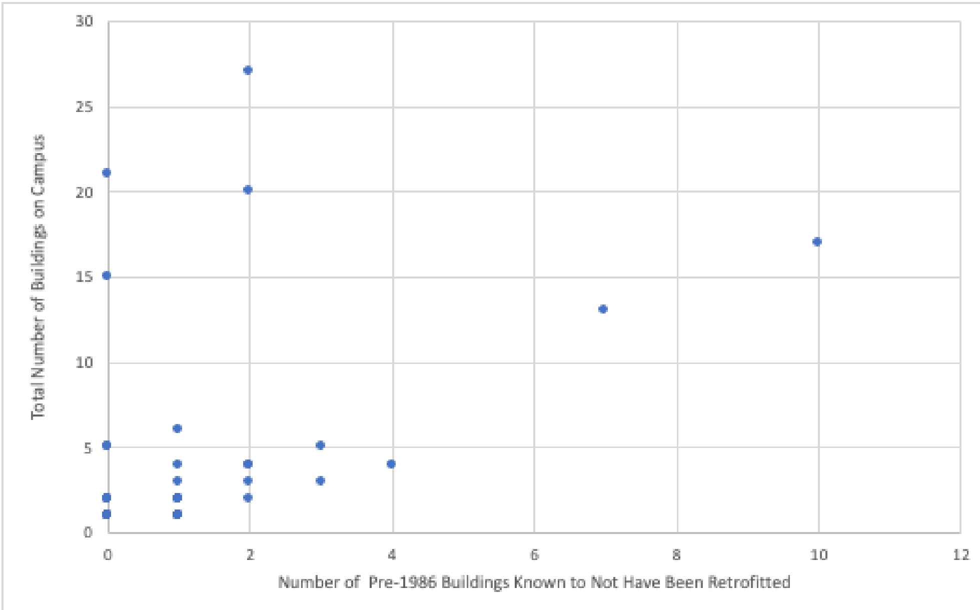
Known Retrofitting History of Pre-1986 Buildings by County

County	Total Pre-1986 Buildings	Retrofitted after 1986	Not Retrofitted After 1986	Unknown to Have Been Retrofitted After 1986
Alameda	17	1	9	7
Contra Costa	15	1	1	13
Marin	13	2	2	9
Napa	15	5	7	3
San Francisco	11	4	2	5
San Mateo	25	10	11	4
Santa Clara	76	14	10	52
Solano	n/a	n/a	n/a	n/a
Sonoma	7	2	4	1
Total	**179**	**39**	**46**	**94**

Of the 68 participants who completed the survey, only 39 were able to definitively state whether their schools had non-retrofitted pre-1986 buildings, and 15 of those respondents claimed that their campus had no buildings that fit these criteria. In order to determine whether a correlation exists between a school's total number of buildings and the likelihood that some of these buildings do not meet modern seismic safety standards, the responses of these 39 participants were converted into the scatter plot shown in Figure 1 below. The y-axis represents the total number of buildings for each school, while the x-axis represents the number of buildings known to have been constructed before 1986 and not renovated since.

Figure 1

Number of Pre-1986 Buildings by School



Based on the responses to the survey and the chart above, there is no clear correlation between a private school's total number of buildings and the number of those buildings that are unlikely to meet modern seismic safety standards based on their construction history. Schools with five or fewer total buildings are shown to possess between 0-4 pre-1986 buildings, schools with 5-15 buildings are shown to possess between 0-7 pre-1986 buildings, and schools with 15 or more buildings are shown to possess between 0-10 pre-1986 buildings. Again, these data were collected from a random sample of 39 schools of the 699 schools in the Bay Area and is not necessarily representative of the total population. Had a separate set of schools participated, it is possible that Figure 1 would appear differently.

Consolidating data from Tables 3 and 4 permits an estimation of the number of private school buildings in participating schools that may be expected to perform well during an earthquake. Because the Private Schools Building Safety Act was enacted in 1986, buildings constructed or renovated after 1986 were assumed to perform well during an earthquake.

Buildings constructed prior to 1986 with no known subsequent renovations were considered potentially unsafe, and buildings with no known date of construction were separated into a third category. The results are presented in Table 5 below.

Table 5

Comparison of Private School Buildings Assumed to be Seismically Safe vs. Potentially Unsafe by County

County	Total Buildings	Buildings Designed to be Safe During an Earthquake	Buildings Considered Potentially Unsafe	Buildings with Unknown Construction Year
Alameda	39	5	16	18
Contra Costa	21	4	14	3
Marin	25	14	11	0
Napa	16	6	10	0
San Francisco	12	5	7	0
San Mateo	75	59	15	1
Santa Clara	118	56	62	0
Solano	n/a	n/a	n/a	n/a
Sonoma	16	11	5	0
Total	**322**	**160**	**140**	**22**

The 68 private schools that participated in the survey possess a combined 322 buildings. At least 140 (43.5%) of these private school buildings were constructed before 1986 and have either not been retrofitted since or are not known to have been retrofitted since. Considering that any of the 22 buildings for which the construction history is unknown may, in fact, have been constructed before 1986 without subsequent retrofitting, the actual number of potentially unsafe buildings lies within the range of 140-162, or 43.5-50.3%. At least 160 (49.7%) of the private school buildings were constructed or retrofitted after 1986 and are therefore assumed to adhere to modern seismic safety standards. Considering that any of the 22 buildings for which the construction history is unknown may have been constructed or renovated after 1986, the actual number of buildings ranges from 160-182, or 49.7-56.5%.

Factors in Selecting Organizations for the Design and Construction of New Buildings

The final portion of the survey asked participants to identify which of the following factors played a role in the school's decision to select one organization or another for the design and construction of new buildings: the cost of the project compared to similar organizations; the estimated duration of construction compared to similar organizations; a personal relationship with an employee of the organization; whether the organization has prior experience in constructing private school buildings; recommendation from peer schools; and whether the organization has higher safety standards compared to similar organizations. Participants were permitted to select as many factors as they felt were relevant. The results are provided in Table 6 below.

Table 6

Factors in Selecting Design and Construction Organizations by County

County	Total Schools	Project Cost	Project Duration	Personal Relationship	Prior Exp.	Peer Recom-mendation	Higher Safety Standards
Alameda	9	8	7	3	7	4	6
Contra Costa	8	7	6	2	3	3	5
Marin	3	3	2	0	2	2	3
Napa	2	2	2	0	1	2	2
San Francisco	8	7	2	1	4	6	3
San Mateo	11	10	6	3	6	7	6
Santa Clara	15	13	7	6	10	9	7
Solano	0	n/a	n/a	n/a	n/a	n/a	n/a
Sonoma	5	3	1	2	2	2	2
Total	**61**	**53**	**33**	**17**	**35**	**35**	**34**

The most common influencing factor is the total cost of construction compared to similar organizations. Project duration, prior experience, recommendations from peer schools, and higher safety standards were about equal, and the least common factor was a personal relationship with a member of the organization. While the survey did not ask administrators to rank the influencing factors by order of importance, it is clear that schools consider a variety of factors when choosing between candidates for the design and construction of new buildings.

ANALYSIS

Discussion

While a participation rate of approximately 10% does not permit a thorough assessment of private school buildings in the San Francisco Bay Area, the responses received do offer some insight into the accessibility of information pertaining to private schools, the PSBSA's influence on Bay Area schools, the variability in schools with potentially unsafe buildings, and schools' values when considering the construction of new buildings.

As shown in Table 3, the 68 participating schools have a combined 322 buildings, at least 179 of which were built before the PSBSA was enacted in 1986. Even if all 22 buildings of unknown construction date were all built after 1986, the number of post-1986 buildings would total 143 of 322, or 44.4%. While a building's date of construction is not in itself an indicator of its overall seismic safety, it is useful to know that pre-1986 buildings constitute a large percentage of school infrastructure in approximately 10% of Bay Area private schools, since older buildings are potentially more at risk.

Knowing whether a pre-1986 building has been retrofitted is more useful in estimating its seismic safety than its construction year alone. Table 4 shows that, of the 179 pre-1986 buildings, 39 (21.8%) are known to have been retrofitted after 1986, 46 (25.7%) are known not to have been retrofitted after 1986, and 94 (52.5%) buildings are unknown to have been retrofitted. While a high percentage of uncertainty is unhelpful in estimating a building's performance during an earthquake, it is not surprising that school administrators are unfamiliar with all the modifications a building may have experienced over the past 35 years. Table 4 further demonstrates a high degree of variability between counties. Alameda County had both the smallest percentage of known retrofitted buildings (5.9%) as well as the second-highest percentage of retrofitted buildings (52.9%), despite a strong percentage of unknown buildings (41.2%). Contra Costa and Marin Counties had very little information available, despite having approximately the same number of buildings as three other counties. San Mateo County had both the second-highest number of pre-1986 buildings and the second-lowest percentage of buildings (16%) unknown to be retrofitted, while Santa Clara County had more “unknown” buildings than the other seven counties combined. Sonoma County, having the fewest number of pre-1986 buildings of participating counties, qualifies as having the highest percentage of known-retrofitted buildings and the smallest percentage of buildings unknown to be retrofitted. While there is a degree of variability regarding status of pre-1986 buildings between counties, it should be noted participating schools served as a random sample of all private schools in the Bay Area, and may not be representative of private schools overall. The dismal ratio of known retrofitted buildings and the disproportionately high number of buildings unknown to be retrofitted leads one to hope that Table 4 does not, in fact, reflect the totality of schools. Thousands upon thousands of students and employees are inside private school buildings on a regular basis. The fact that 78.2% of pre-1986 buildings were either not retrofitted or are not known to be retrofitted is cause enough for concern.

While Figure 1 is primarily intended to demonstrate a lack of correlation between a school’s total number of buildings and its number of non-retrofitted pre-1986 buildings, it also serves as a reminder that more information is needed in order to draw reliable conclusions about the state of private school buildings in the Bay Area. Had more schools participated in the study, or had a different 68 schools responded to the survey, the scatter plot might have taken a different form than it does here. Most importantly, Figure 1 should caution the reader against using the aggregated data in Table 5 to form generalizations about all private schools in each county or the Bay Area overall.

Table 5 shows that 49.7% of private school buildings in participating schools are expected to perform well during an earthquake, 43.5% of private school buildings are considered potentially unsafe, and that additional information is needed for 6.8% of buildings to make a determination. There are two points to consider when interpreting this information. First, while this method of deduction was designed to follow that of the Seismic Safety Commission when surveying public school buildings in response to AB 300, the true seismic safety of any building can only be determined by a certified inspector with expertise in design and construction standards. It may be that some pre-1986 buildings were designed and constructed to exceed the safety standards of the time so that they adhere to modern criteria as well. It may also be the case that buildings that were constructed or retrofitted after 1986 did not adhere to the safety standards that they should have. Only a qualified inspector can make that determination. Secondly, while California's public schools have shown great resilience against earthquakes following the enactment of the Field Act, they are not necessarily "earthquake-proof." Buildings are designed to withstand seismic forces that are characteristic of the region in which they are built, and there is a possibility that the magnitude of an earthquake will exceed expectations or that there will be other factors that compromise a building's durability.

That said, the fact that 43.5% of this sample's private school buildings are considered potentially unsafe is alarming. When considering which school to attend, prospective students and their families will inquire about athletics, academics, class sizes, and cost, because these are a school's most visible qualities and are often the most appealing. Design and construction standards for school buildings, however, are not standard discussion points. Parents assume that their children's life-safety is a given; they may not think to ask whether the school's buildings are safe in the first place, and, as shown in Table 4, employees may not know the answer.

Finally, Table 6 demonstrates that multiple factors are considered when choosing between organizations for the design and construction of new buildings. Some participants selected only one factor as being relevant, while others stated that all factors were of importance. It is likely that each of these factors will be taken into consideration to some extent, and that the final decision will be made after multiple consultations with prospective organizations. It is also likely that, for each school, there will be a number of people involved in the decision to choose an organization to design and construct new buildings, including high-level administrators, the board of directors, and trustees. Other factors, such as the availability of competing organizations to choose from, prior experience using an organization for previous projects, and the quality of personal interactions with representatives from each organization will also influence the outcome. Ultimately, each school will want the building to serve its intended purpose, improve the school's perceived value to current and future students, conform to legal requirements, and be constructed with little inconvenience.

Potential Limitations

As shown in Table 2, over 90% of private schools were unwilling or unable to participate in the survey. While conducting a survey was the most efficient method of collecting data from a large number of schools, the approach is limited in three respects. First, as contact information was obtained from the California Department of Education, schools with outdated or misspelled email addresses would not have received the survey. Secondly, participation in the survey was voluntary. The administrators were free to decline to participate, which consequently reduced the amount of data available for analysis. Finally, the survey was distributed during the COVID-19 pandemic in which the majority of school employees were working remotely. Had participants required access to on-campus resources or assistance from coworkers to respond to survey questions, working remotely could have prevented them from completing the survey. In order to develop an inventory of private school buildings as thorough as that mandated by AB 300, a regulatory agency would either need to coordinate thorough inspections of schools or dedicate personnel to evaluate existing records. Until that happens, the seismic safety of Bay Area private school buildings will remain unknown.

Areas for Future Study

For the purposes of this paper, the term “safety standards” referred to stringent standards pertaining to the design, construction, and inspection of school buildings. However, for those participating in the survey, particularly when providing data presented in Table 6, the term may have been understood differently. When respondents claimed that “heightened safety standards” was an appealing quality in prospective organizations, it is unclear to which standards they were referring. Further research on a school’s understanding of the term would therefore be beneficial.

Secondly, it is unclear whether private schools value retrofitting pre-1986 buildings as much as they value ensuring that new buildings are seismically safe. It is unclear to what extent administrators consider the adequacy of existing buildings in the first place, or whether they assume without proof that a building’s safety is sufficient. Further research about private school employees’ presumptions about their physical workplace would be helpful in developing a sociological understanding of employees’ assumptions about safety standards.

Finally, it is unclear whether the effectiveness of the PSBSA was inhibited by its being placed in the California Education Code rather than the California Building Code. Future research on this topic would likely require extensive interviews with architects, construction companies, civil servants, and school administrators across the state. While such efforts exceeded the capacity of this study, this information would be invaluable in determining whether the PSBSA had an impact on the way private schools considered the safety of their students and employees.

CONCLUSION

Design and construction standards tend to improve after disasters. Buildings and infrastructure are, on the whole, safer today than they were at the inception of the 20th century. Fires, floods, and earthquakes lead to greater understanding of which materials, procedures, and standards are most effective in protecting communities against the formidable forces of the planet. In California, the Field Act was a response to the Long Beach earthquake of 1933 and it resulted in public schools having among the safest buildings in the state. The effects of the Private Schools Building Safety Act of 1986, however, are disputable. To date, 35 years after the Act was passed, it is unclear whether it resulted in safer private school buildings, educated school employees about the importance of higher safety standards, or impacted organizations responsible for the design and construction of private school buildings. Nobody appears to know what percentage of private school buildings can be expected to perform well during an earthquake. The dearth of information and lack of centralized data indicate that the Private Schools Building Safety Act did not have a meaningful impact on California's residents. This is an unfortunate conclusion, yet it is not unexpected. The Act stated the importance of improving safety standards, but did not mandate reformation of private school construction policy. No regulating agency was charged with overseeing private school construction, no effort has been made to assess the current state of existing buildings, and educating the public appears to be voluntary. Maybe, in time, a large earthquake will lead to further reform. The Act's failings may be costly, perhaps tragic, but it will certainly teach legislators the importance of crafting well-designed policies.

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Appendix A

Side-by-side comparison: Field Act and the Uniform Building Code

Field Act Title 24, CCR for Public Schools	**Uniform Building Code for Private Schools**
Administrative Requirements	
Design Professionals	
An architect or a structural engineer must be in general responsible charge of the design and construction.	In addition to an architect and structural engineer, a civil engineer is also allowed to be, in general, responsible charge of the design and construction.
Plan Approval Process	
Requirements for submitting the site data, geologic hazard reports, calculations, change orders are provided in detail. The process of reviewing, marking the plans, and verification of corrections are delineated.	Detailed requirements are not provided.
Inspection	
Continuous inspection by an inspector, approved by the Division of the State Architect (DSA), is required.	Periodic special inspection at construction milestones (i.e. before concrete placement, before structural framing, gypsum board inspection).
Verified Reports	
The inspector is required to provide a verified report under penalty of perjury attesting that the construction is in compliance with the approved plans and specifications based on personal knowledge provided by continuous inspection.	No similar report is required.
The architects, engineers, and contractors are required to provide a verified report under penalty of perjury attesting that the construction is in compliance with the approved plans and specifications based on periodic visits to the site and the reporting of	No similar report is required.

others.	
Structural Requirements	
Bleachers	
Additional details and inspection requirements above the UBC.	No similar requirements.
Dynamic Analysis	
A calculation is required to determine if an earthquake with at 10% probability of exceedance in 100 years would cause a collapse is required, in addition to the 10% in 50 years calculation of the design of a structural system.	The structural design to resist the forces for the 10% probability is the same as Title 24, CCR. There is no similar 10% probability in 100 years collapse evaluation required.
Foundation Strength	
Additional requirements above the UBC for foundation and superstructure-to-foundation connections.	
Elevators	
The design for stability of the elevator system is subject to additional requirements above the UBC.	
Classroom Floor Loads	
50 pounds per square foot.	40 pounds per square foot.
Seismic Importance Factor for Occupancy over 300	
I = 1.15	I = 1.00
Wind Importance Factor for Occupancy over 300	
I = 1.15	I = 1.00
Precast Concrete Walls	

Additional reinforcing is required above the UBC.	
Post-tensioned Precast Concrete	
Additional requirements for anchorages and couplers. Lift slab construction, and flat slab construction are indicated.	
Expansion Anchors in Concrete	
Tension testing is required.	Tension testing is not required.
Bolts Embedded in Concrete	
Allowable loads are much smaller when the force on the bolt is directed towards the edge of the concrete. For example, a 1-inch diameter bolt placed 6 inches from the edge would have an allowable shear value of 1,700 pounds.	A one-inch bolt placed six inches from the edge would have an allowable shear value of 4,500 pounds.
Masonry Construction	
All cells filled solid with grout.	Optional based on stresses.
Wall reinforcing spacing two feet on center.	Wall reinforcing spacing four feet on center.
Masonry core testing is required.	Masonry core testing is not required.
Wood Construction	
Glue-laminated beams special inspection required.	Glue-laminated beams special instruction not required.
Gypsum sheathing board is not allowed to resist lateral forces.	Gypsum sheathing board is allowed to resist lateral forces.
"Conventional" wood framing design is not allowed. A project-specific design is required.	"Conventional" wood framing design is allowed. The use of standard sizes and spacing of wood members for design.

Adapted from "Seismic Safety in California's Schools," California Seismic Safety Commission, 2004, https://sfgov.org/esip/sites/default/files/FileCenter/Documents/10639-CSSC_2004-04_School%20Safety.pdf

APPENDIX B

Timeline comparing regulations covering San Francisco private school and public school building design and construction, grades K-12.

Date of Building Construction	**Public Schools**	**Private Schools**
Schools built before 1933 (pre-Field Act)	All California public school buildings built before 1933 have been evaluated and, if found to be unsafe, have been seismically retrofitted or removed from use. Some school buildings retrofitted before the mid-1970s might be seismically unsafe . These schools are on the AB 300 list	Some private school buildings built in this time period might be seismically unsafe. San Francisco private school buildings built in this time period were not required to meet any earthquake-related code requirements. Only unreinforced masonry schools with load bearing walls have been required to be seismically retrofitted. In general , other private schools have not been required to be seismically evaluated or retrofitted.
Schools built between 1933 - 1948 (post Field Act , pre SF Building Code seismic provisions)	Some public school buildings from this time period might be seismically unsafe , particularly those that are not wood-frame structures. These schools are on the AB 300 list. Public school buildings built in this time period were subject to the codes and regulations of the Field Act. Public school buildings from this time period have not	Some private school buildings built in this time period might be seismically unsafe. San Francisco private school buildings built in this time period were not required to meet any earthquake-related code requirements. In general, private school buildings from this time period have not been required to be seismically evaluated or retrofitted.

	been required to be seismically evaluated or retrofitted.	
Schools built between 1948 – 1978 (post SF Building Code seismic provisions , pre concrete lessons)	Some public school buildings from this time period might be seismically unsafe , particularly those that are not wood-frame structures. These schools are on the AB 300 list. Public school buildings built in this time period were subject to the codes and regulations of the Field Act. Public school buildings from this time period have not been required to be seismically evaluated or retrofitted.	Some private school buildings built in this time period might be seismically unsafe , particularly those that are not wood-frame structures. New San Francisco private school buildings from this time period were required to incorporate some seismic resistant design features. The code requirements for new private school buildings improved periodically over this time period. In general, private school buildings from this time period have not been required to be seismically evaluated or retrofitted.
Schools built between 1978 – 1984 (State code reflects concrete lessons but SF code does not)	Most public school buildings constructed during this time period are expected to be seismically safe.	Some private school buildings built in this time period might be seismically unsafe , particularly those that are not wood-frame structures. San Francisco private school buildings built during this time period were required to incorporate some seismic resistant design features, but the San Francisco Building Code did not yet incorporate all important structural safety provisions for reinforced concrete buildings. In general, private school buildings from this time

		period have not been required to be seismically evaluated or retrofitted.
Schools built between 1984 – 1987 (SF code reflects all concrete lessons)	Most public school buildings constructed during this time period are expected to be seismically safe.	Most private school buildings constructed during this time period are expected to be seismically safe. In 1984, The San Francisco Building Code was updated to incorporate the requirements of the 1979 Uniform Building Code, which included important structural safety provisions for reinforced concrete buildings.
Schools built between 1987 – present (Private Schools Act enacted)	Most public school buildings constructed during this time period are expected to be seismically safe.	Most private school buildings constructed during this time period are expected to be seismically safe. The State enacted the Private Schools Building Safety Act in 1987, which requires a similar, but somewhat lower, level of safety than what is required for public school construction

Adapted from "Earthquake Risk and San Francisco's Private Schools," Earthquake Safety Implementation Program, 2013, https://sfgov.org/esip/sites/default/files/FileCenter/Documents/11392-Earthquake%20Risk%20and%20San%20Franciscos%20Private%20Schools%2012-31-13%20REPORT.pdf

APPENDIX C

Private Schools Building Inventory Questionnaire

1. In which county is your school located?
    a. Alameda County
    b. Contra Costa County
    c. Marin County
    d. Napa County
    e. San Francisco County
    f. San Mateo County
    g. Santa Clara County
    h. Solano County
    i. Sonoma County
2. In what year was your school founded?
    a. Open text response ___________
3. How many grade levels between kindergarten and 12th grade are taught at your school?
    a. Open text response ___________
4. Approximately how many students attend your school?
    a. 10-50
    b. 50-100
    c. 100-200

d. 200-300

e. 300-400

f. 400-500

g. 500+

5. Approximately how many faculty and staff are employed at your school?

   a. Open text response ___________

6. How many buildings does your school have?

   a. Open text response ___________

7. How many of these buildings were constructed prior to 1986? Please write "unsure" if the quantity is unknown.

   a. Open text response ___________

8. Of the buildings that were constructed prior to 1986, How many of these buildings have been retrofitted since 1986? Please write "unsure" if the quantity is unknown.

   a. Open text response ___________

9. Of the buildings that were constructed prior to 1986, How many of these buildings have NOT been retrofitted since 1986? Please write "unsure" if the quantity is unknown.

   a. Open text response ___________

10. How many buildings in your school were constructed after 1986? Please write "unsure" if the quantity is unknown.

    a. Open text response ___________

11. Unreinforced masonry buildings are considered unsafe during high magnitude earthquakes. Examples of unreinforced masonry include bricks, tiles, or cinderblocks that are not strengthened by reinforcing materials such as rebar.

    How many of your buildings are constructed from the materials above? Please write "unsure" if the quantity is unknown.

    a. Open text response ___________

12. Some private school buildings may be exempt from the California Private Schools Building Safety Act if they are all of the following: (a) one-story, (b) contain 2,000 square feet or less of floor space, and (c) are wood-framed or non-combustible

    To the best of your knowledge, how many buildings in your school meet these criteria? Please write "unsure" if the quantity is unknown.

    a. Open text response ___________

13. Are you planning to construct new buildings within the next five years?

    a. Yes

    b. No

    c. Unsure

14. Are you planning to retrofit existing buildings within the next five years?

    a. Yes

    b. No

    c. Unsure

15. Which of the following factors do you take into consideration when choosing between organizations for the design and construction of buildings? Please check all that apply.

a. The estimated cost of the project compared to similar organizations.

b. Estimated time of project completion compared to similar organizations.

c. A personal relationship with a member of the organization.

d. Whether the organization has prior experience in constructing private school buildings.

e. Recommendations from peer schools.

f. Heightened safety standards compared to other organizations.