Is Construction Blasting Still Abnormally Dangerous?

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Abstract: The main premise of this paper is that construction blasting is no longer an abnormally dangerous activity using the six factors presented in Section 520 of the Second Restatement of the Law of Torts. Though blasting is considered to be the paradigm strict liability activity, it appears to be more appropriate to regulate it using the general negligence framework for tort liability because of advances in blasting technology over the past 40 years. This paper examines the current application of strict tort liability for nontrespassory effects of construction blasting, presents advances in construction blasting technology that allow control of nontrespassory blasting effects on adjacent structures, and analyzes the six factors presented in Section 520 of the Second Restatement of the Law of Torts used to determine whether or not an activity is abnormally dangerous.

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Introduction

The two types of blasting damages are trespassory (flying debris) and nontrespassory (ground vibrations and air overpressures). Strict tort liability has been applied to damages caused by flying debris, e.g., rocks, soil, or other material, being cast upon a nearby property as early as 1893.[1] This conclusion is justifiable based on the theory that debris was projected onto a neighboring property and is abnormally dangerous. Recovery for fly debris can also be sought via trespass and nuisance.[2] Under a strict tort liability framework, a plaintiff only has to prove that the blasting is the cause of the claimed damage to the property and the amount of the damage inflicted.

The more difficult issue is the treatment of nontrespassory damages. Currently most courts (38 out of 50) and relevant authorities do not distinguish between trespassory and nontrespassory damages and apply strict tort liability to both damages.[3] For example, the Iowa Court concludes that trespassory and nontrespassory phenomena are both physical invasions and thus should be treated as trespassory.[4] Prosser states only five or six courts continue to adhere to the ancient distinction between trespassory and nontrespassory damages and treat nontrespassory on the basis of negligence.[5] This leaves six or seven states that are not well defined in terms of trespassory and nontrespassory damages. This paper examines the current application of strict tort liability to nontrespassory effects of construction blasting, presents advances in construction blasting technology that allow control of nontrespassory blasting effects on adjacent structures, and analyzes the six factors of Section 520 of the Second Restatement of the Law of Torts[6] (American Law Institute 1977) for determining whether or not an activity is abnormally dangerous to show that construction blasting could be evaluated using a negligence framework.

Commercial Blasting

The use of commercial explosives is confined to four major applications: coal mines (54% of commercial blasting), construction and miscellaneous blasting (16%), metal mines (15%), and nonmetallic mines and quarries (15%) (Dowding 1996).[7] The mining, quarrying, and construction industries use over 4 billion pounds (1.8 billion kg) of commercial explosives per year in the United States to facilitate rock excavation activities.[8] Construction projects that typically utilize blasting include tunnels,[9] roadways/highways,[10] trenches, and other excavations, such as for utilities or building foundations,[11] railroad roadbeds,[12] quarry operations,[13] mining,[14] removing boulders from a stream bed to prevent flooding,[15] sewer construction,[16] underwater dredging operations,[17] lock and dam construction,[18] seismic explorations of the subsurface,[19] and stabilizing rockslides.[20]

Mining blasting is extensively regulated on the federal and state levels, whereas construction blasting is largely unregulated, even though it usually occurs in more populated areas than mining blasting. Mining blasting regulations have developed because the largest percentage of blasting (84%) relates to mines and quarries and is much more common than construction related blasting. The objectives of mining and construction blasting differ with the main objective of mining blasting being to fragment large amounts of rock to facilitate excavation and processing of the rock while in construction blasting the main objective is to sculpt an opening or excavate a well-defined area to facilitate construction while not impacting adjacent ground or structures. Thus, construction blasting typically requires a much greater degree of control than mining related blasting which can lead to the use of a large amount of explosives being used. Because of the greater control required, construction blasting usually satisfies mining re-

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lated regulations. However, construction blasting usually results in more litigation because of the many adjacent structures. Because of the greater amount of litigation, the focus of this paper is construction not mining related blasting.

Construction Blasting-Induced Damages

Nontrespassory damages are caused by ground vibrations and air pressures, which are referred to as air overpressures in the blasting industry because the blast-induced air pressure augments the omnipresent atmospheric pressure (Oriard 1999).[21] Courts have also used the term concussion[22] damage to describe air overpressure damage. The imposition of strict tort liability for nontrespassory blasting damages has led to considerable litigation over minor or cosmetic cracking in structures.[23] This has resulted in many frivolous claims and impressions about blasting and has limited or restricted the use of blasting in construction activities.[24] In some cases, the strict tort liability framework has allowed damage allegations to be accepted even though the cosmetic cracking was not caused by blasting activities.[25] This has also resulted in dubious expert qualifications and testimony, e.g., *Ballard v. Buckley Powder Co.*[26] In this case the expert had no training or education in blasting, had never worked for a blasting company, had never given advice to a blasting company, had never designed a blast, and had never operated any seismic recording devices to record the effect of a blast."[27] Between his first and second depositions, the plaintiff's expert "obtained information on blasting from the internet, spoke briefly with alcohol, tobacco, and firearms personnel, and learned from the Kansas state fire marshal that a license is required to conduct blasting in Kansas."[28] However, this expert testified that nearby blasting damaged the plaintiff's house.[29]

The imposition of a negligence framework for nontrespassory blasting damages may reduce the number of unwarranted claims, raise the level of expertise required for experts, and increase the use of blasting as a cost-effective excavation technique while protecting the interests of the public and property owners. It will be shown that current blasting technology can be used both to design blasting programs that result in ground vibrations and air overpressures that are not injurious to adjacent property or structures and to accurately predict vibrations and air overpressures that will occur.

Current Application of Strict Tort Liability to Nontrespassory Blasting Damages

A seminal case for applying strict tort liability instead of negligence for nontrespassory blasting damages is *Spano v. Perini Corporation*[30] in 1969. From 1893 to 1969, the Court of Appeals of New York followed a negligence framework for nontrespassory damages for construction blasting based on *Booth v. Rome, Watertown and Ogden Terminal Railroad Company*.[31] The *Booth* Court reasoned that applying strict liability to nontrespassory blasting damages would be "far reaching" and would constitute "a serious restriction upon the use of property."[32] The Court used Manhattan Island as an illustration of the potential for property restriction under strict tort liability because bedrock is near the ground surface in Manhattan, which makes blasting necessary and/or desirable for excavations.[33] The application of a negligence framework for nontrespassory blasting damages resulted in the plaintiffs having to show a lack of care, i.e., a breach of duty, for recovery of damages alleged to have occurred from the railroad blasting.[34]

In 1969 the *Spano* Court rejected the negligence framework used in Booth and implemented strict tort liability for construction blasting in New York. At the time of Spano 32 jurisdictions held a blaster absolutely liable for nontrespassory as well as trespassory damages,[35] whereas 11 jurisdictions, including New York, held a blaster not liable for nontrespassory damages unless the blaster had been negligent.[36] Definitive case law is not available for the seven remaining jurisdictions (Alaska, Florida, Idaho, Minnesota, Nevada, North Dakota, and Wyoming) in 1969.

Spano owned a garage in Brooklyn, N.Y. that was damaged by a blast on November 27, 1962.[37] The undisputed blast involved a total of 194 0.5-lb (0.23-kg) sticks of dynamite for a total charge of 97 lb (44 kg) of dynamite[38] at a construction site that was only 125 ft (38.1 m) away from the garage.[39] The blasting was conducted to facilitate construction of a water supply tunnel.[40] A lessee of a portion of the premises testified that there was "no damage on or to the premises prior to November 27."[41] This witness also testified that he heard the explosion on November 27 around noon while he was working "some three blocks away" and when he returned to the property a few hours later, "the building was cracked in the wall, the window broke, and the cement floor all pop up."[42] The trial judge awarded damages based on evidence for proximate cause and damages.[43] The Appellate Term reversed because the "established rule in this state" requires proof of negligence and the Appellate Division affirmed.[44] The Court of Appeals of New York reversed and declared that "one who engages in blasting must assume responsibility and he is liable without fault for any injury he causes to neighboring property."[45]

The Spano Court overturned the use of negligence for nontrespassory blasting damages for the following reasons: (1) existing state and out-of-state court decisions use strict tort liability for construction blasting; (2) individual property rights are a concern; (3) strict tort liability is used for accidental explosions; (4) it is difficult to prove negligence in blasting cases; (5) blasting involves a substantial risk of harm; and (6) it is problematic to determine which party should bear liability for blasting damages.[46]

The defendants in the Spano case also only argued causation and not standard of care and thus the trial judge assumed that the plaintiff only had the burden of proof on causation and damages and not breach of duty.[47] The plaintiff satisfied the burden of proof on causation by the blast occurring on November 27, 1962 and the previously undamaged garage being found damaged after the blast based on testimony.[48] The Spano case is still followed in New York as of 2009.

Advances in Blasting Technology

Since the Spano decision almost 40 years ago, substantial advancements in blasting technology have occurred. Some of these developments include new blasting products, transportation and storage techniques, blasting procedures, and guidelines that protect adjacent structures from vibration induced damages.[49] The damages observed in Spano's garage are predictable with these techniques given the amount of explosives detonated and the distance between the blast and the garage as shown below.

Historical Review of Blasting Technology

Siskind[50] presents a historical review of the development of blasting technology based on 40 years of blasting research at the

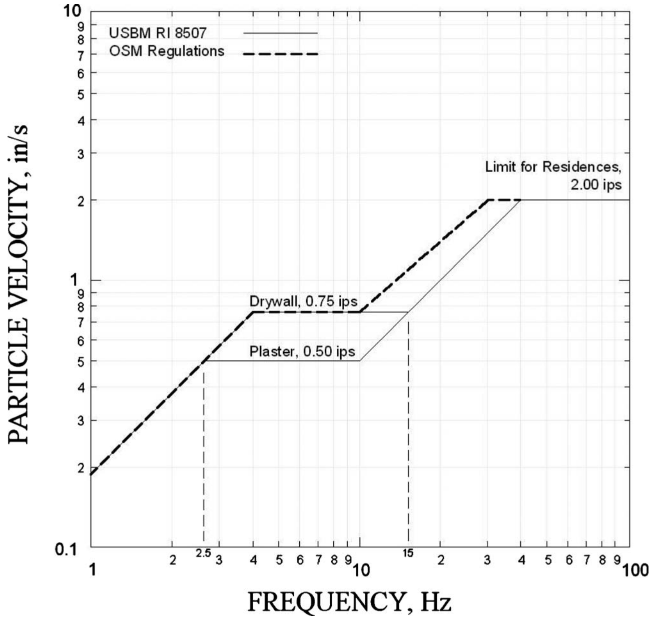

Fig. 1. Safe levels of blasting for residences from USBM RI 8507 (Siskind et al. 1980a) and the OSM surface coal mine regulations that differ slightly between frequencies of 10 and 40 Hz

United States Bureau of Mines (USBM). The main task of the USBM over this 40-year period was to develop safe blasting criteria for residential-type structures near blast sites.[51] This research resulted in four major reports with comprehensive vibration criteria and a comprehensive and reliable criterion published in 1980.

In 1980 the USBM published comprehensive reports on vibration, RI 8507,[52] and air overpressure, RI 8485.[53] In RI 8507 the frequency of vibration is combined with the peak particle velocity to develop vibration criteria that prevent hairline or cosmetic cracks in residential structures.[54] The frequency of vibration is the number of oscillations that occur in 1 s and the value of frequency is presented in units of hertz, where 1 Hz equals 1 cycle/s.[55] The dominant frequency of the blast is the frequency at the peak particle velocity, which can be estimated from a seismograph record for the half-cycle of vibration that has as its maximum the peak particle velocity.[56] The frequency is important because different structures respond differently when subjected to vibrations equal in all respects except frequency.[57] For example, at a peak particle velocity of 0.5 in./s, a dominant frequency of 80 Hz is less likely to crack a residential structure than a frequency of 10 Hz, as shown in Fig. 1.[58] Fig. 1 shows that a safe (no damage) peak particle velocity is about 0.5 in./s for plaster and 0.8 in./s for drywall at a frequency of 10 Hz versus 2.0 in./s for a frequency of 80 Hz.

Frequency is equal to the reciprocal of the duration of the vibration. Thus, a high frequency means a short duration of vibration and a low frequency means a long duration of vibration. The frequency of construction blasts is much greater than the frequency of an earthquake. Thus, blasting vibrations have a much shorter duration (higher frequency) than earthquakes, which have long durations (low frequencies). This helps explain the greater structural damage usually observed by earthquakes than construction blasting.

The peak particle velocity is the maximum rate of change with respect to time of the particle displacement measured on the ground surface in units of in./s. Velocity, displacement, or acceleration of a point in the ground can be measured to give the motion at that point or "particle."[59] These measurements produce time history records of velocity, displacement, and acceleration for the blast like those measured during an earthquake.[60] The peak particle velocity varies with blasting parameters, such as the magnitude of the charge, the amount of time allowed between detonations, the distance from the explosion to the particular structure, and type of structure and it is used by the USBM to predict damage to adjacent structures.

Estimating Blast-Induced Vibrations

Three blasting methodologies based on peak particle velocity allow blasters to predict and control the level of vibration that will be induced on adjacent structures from a particular blast. These methodologies can also facilitate a plaintiff proving that a blaster was negligent. The three methodologies are used in federal[61] and state[62] mining related regulations and can be used as mere evidence of or against negligence if the strict tort liability framework for construction blasting is abandoned. These techniques are illustrated using the Spano case.

The first method uses past blasting research and experience to calculate the peak particle velocity induced in a structure for a given construction blast. Oriard[63] presented the following expression that allows the peak particle velocity to be calculated using the blast distance and the maximum explosive weight per detonation delay:

$$V = 242\left[\frac{D}{\sqrt{W}}\right]^{-1.6} \quad (1)$$

where V=peak particle velocity in in./s; D=distance from the blast in feet; and W=maximum explosives' weight per detonation delay in pounds.

This equation allows a plaintiff to estimate the peak particle velocity induced by a blast without installation of a seismograph using the distance of the structure from the blast and the amount of explosives used. The amount of explosives used can be obtained from blasting or construction permits, project plans and specifications, deposition testimony, and/or observed damage, as illustrated using the Spano case.

A detonation delay corresponds to the amount of explosive detonated within any 8-ms period of time.[64] This criterion is used in practice and was developed by the USBM and published in RI 6151[65] (Duvall et al. 1963) based on quarry blasting with different delays between blasts and site conditions.[66] At delay times of less than 8 ms, the blast vibrations and air overpressures can be cumulative and result in vibrations and air overpressures that are greater than a single blast.[67] The distance from the blast is usually the closest horizontal distance unless the distance is small, and then it is the slant distance or the distance from the depth of the blast to the structure.[68]

This equation encompasses blasting data obtained by Oriard for a variety of geologic conditions and types of blasting encountered over about 40 years.[69] The equation is frequently referred to as the square root scaling of distance and weight because the weight of the explosives detonated is subject to a square root.[70] The equation can be used to estimate the peak particle velocity at a site before or after blasting.[71] For example, no field measurements are available for the Spano case,[72] but the square root scaling equation can be used to estimate the peak particle velocity induced at Spano's garage by the tunnel blasting.[73] The blast involved a total of 194 sticks of dynamite (97 lb of explosives) at a

Table 1. Range of Common Residential Criteria and Observed Side Effects Based on Peak Particle Velocity[76]

Peak particle velocity (in./ft)	Range of common residential criteria and observed side effects
0.5	U.S. Bureau of Mines (USBM) RI 8507[77] recommends guidelines (USBM 8507) for plaster-on-lath construction near surface mines, i.e., long-term, large-scale blasting operations inducing low-frequency vibrations.
0.75	USBM 8507 recommended guideline for sheetrock/drywall construction near surface mines.
1.0	U.S. Office of Surface Mining[78] (OSM) regulatory limits for residences near surface mine operations at distances of 300–5,000 ft, i.e., long-term, large-scale blasting.
2.0	Widely accepted limit for residences near construction blasting and quarry blasting (USBM 8507). Also allowed by the OSM for blasting frequencies above 30 Hz.
5.4	Minor damage to an average house subjected to quarry blasting vibrations.
9	About 90% probability of minor damage from construction or quarry blasting. Structural damage to some houses. Depends on vibration source, character of vibration, and the house.
20	For close-in construction blasting, minor damage to nearly all houses, structural damage to some. A few may escape damage entirely. For low-frequency vibrations of long duration, major damage to most houses.

construction site 125 ft away.[74] The estimated peak particle velocity from the square root scaling equation is as follows:

$$V = 242\left[\frac{D}{\sqrt{W}}\right]^{-1.6} = 242\left[\frac{125\ \text{ft}}{\sqrt{97\ \text{lb}}}\right]^{-1.6} = 4.2\ \text{in./s} \tag{2}$$

Therefore, a plaintiff would not have to obtain seismograph records to estimate the peak particle velocity to prove negligence, only the distance and weight of explosive per delay. Table 1 shows peak particle velocities and common blasting criteria and side effects. A peak particle velocity of 4.2 in./s significantly exceeds a peak particle velocity of 2.0 in./s, the accepted or safe limit, and thus it would be widely expected that a nearby residence would be damaged by this blast as was the case for Spano's garage.

Table 1 can also be used to estimate the amount of explosives used based on the observed damage and distance from the blast. For example, the Spano garage suffered minor to possibly some structural damage because the concrete floor "popped up."[75] Therefore, the peak particle velocity at the Spano garage is greater than 2.0 in./s and less than 9 in./s with a reasonable estimate being about 5.4 in./s, which corresponds to minor damage to the average house. Using the square root scaling equation, a peak particle velocity of 5.4 in./s, and a distance of 125 ft, the weight of explosives used can be estimated by rearranging Eq. (1) and solving for W:

$$W = 0.001048\left[\frac{D^2}{V^{-1.25}}\right] = 0.001048\left[\frac{(125\ \text{ft})^2}{(5.4\ \text{in./s})^{-1.25}}\right] = 134\ \text{lb} \tag{3}$$

A weight of 134 lb is close to the 97 lb actually used even with estimating the peak particle velocity to be 5.4 in./s.[76] The plaintiff also could conclude that the weight of explosives ranged from 39 to 255 lb based on peak particle velocities greater than 2 in./s and less than 9 in./s, respectively.

The criteria in Table 1 allow blasting to be conducted adjacent to delicate structures without damage. There are many examples of successful construction blasting in urban environments to facilitate economic development in major cities such as Las Vegas. The successful and frequent use of blasting in cities suggests that blasting in an urban area should be a matter of negligence because, like an uninhabited mountainside, it can be performed without great risk of harm to adjacent properties.

The second method to prove or disprove negligence is to measure the vibrations during blasting using a seismograph. If a seismograph is used, the blaster is permitted to induce peak particle velocities below the Office of Surface Mining (OSM)[77] (Office of Surface Mining Reclamation and Enforcement 1983) levels shown in Table 2. If the measured values exceed the values in Table 2, the plaintiff can use this exceedance as mere evidence that the blaster is negligent. Conversely, the blaster can use seismograph data to rebut causation of observed cosmetic cracking by showing that the measured peak particle velocities did not exceed the criteria in Table 1.

The third method to facilitate proof of negligence is similar to the second method except that the maximum explosive weight detonated in any 8-ms period and the distance from the blast are used to calculate the scaled-distance (SD) factor for comparison with the SD factors in Table 2. The advantage of this method is that the blaster does not have to install seismographs. The SD factor is calculated using the following expression:

$$\text{SD} = \frac{D}{\sqrt{W}} \tag{4}$$

If the calculated value exceeds the values in Table 2, the blaster exceeded the allowable values presented by the OSM, which is evidence of negligence. Conversely, a blaster could rebut a negligence claim by showing that the explosives' weight does not exceed the weight corresponding to the SD factors in Table 2. This third method is important because the USBM has shown that

Table 2. Allowable Peak Particle Velocities as a Function of Distance from OSM Regulations if a Seismograph Is Installed[81]

Distance from blast (ft)	Permitted peak particle velocity (in./ft)	SD factor used without seismic monitoring ($\text{ft/lb}^{1/2}$)
0–300	1.25	50
301–5,000	1.00	55
Greater than 5,000	0.75	65

no damage will occur to a structure if the explosives used do not exceed the SD factors in Table 2,[78] and these SD factors have been adopted in state and federal regulations.

Eq. (4) can be rearranged to calculate the allowable explosives' weight detonated in any 8-ms period that corresponds to the SD factors in Table 2 as shown

$$W = \left[\frac{D}{\mathrm{SD}} \right]^2 \tag{5}$$

For example, if the Spano blasting was being conducted near a garage and the blaster did not want to incur the expense of installing seismographs, the contractor could use a SD factor corresponding to a distance of 125 ft, i.e., 50 $\mathrm{ft/lb^{1/2}}$ from Table 2, to calculate the maximum explosive weight that could be detonated in any 8-ms period without causing damage as shown below

$$W = \left[\frac{D}{\mathrm{SD}} \right]^2 = \left[\frac{125 \text{ ft}}{50 \text{ ft/lb}^{1/2}} \right]^2 = 6.25 \text{ lb}$$

If the blaster used 6.25 lb of explosives per 8-ms delay, the blaster would be able to rebut a claim of negligence, but under the current strict tort liability framework the blaster can only use this information to rebut whether or not the blasting caused the observed cracking. If the blaster exceeds a charge of 6.25 lb, a plaintiff would have mere evidence that the blaster was negligent. The main disadvantage of using the SD factors in Table 2 is they are extremely conservative. For example, the blaster can only use 6.25 lb of explosives in each 8-ms period versus 21.6 lb obtained using Eq. (1) for the same peak particle velocity of 1.25 in./s and a distance of 125 ft, i.e., Spano's garage. Spano's garage was damaged when an explosive weight of 97 lb was used. The use of 6.25 lb of explosives, based on the OSM regulatory limits, or 21.6 lb of explosives based on Oriard's extensive data[79] probably would not have produced the observed damage.

The SD factors in Table 2 are extremely conservative because they are independent of frequency. A blaster can use higher peak particle velocities if the frequency of the blast is considered, as shown in Fig. 1. These peak particle velocities are the highest values that are allowed and thus the blaster must install "sophisticated seismic monitoring which records the frequency content of the ground vibrations" and peak particle velocity to ensure compliance with the higher values of peak particle velocity.[80]

A comparison of Table 2 and Fig. 1 shows that the maximum allowable peak particle velocity in Table 2 is 1.25 in./s, whereas the less conservative limits in Fig. 1 allow a peak particle velocity of 2.00 in./s at frequencies greater than 30 Hz. The higher peak particle velocity is allowed because the regulatory limit reflects the importance of frequency and thus the different response of structures at different frequencies. For example, a residential structure consisting of drywall can withstand a higher peak particle velocity (0.75 versus 0.5 in./s) than a residence with plaster at a frequency between 2.5 and 15 Hz. This is due to plaster being more brittle and susceptible to damage than drywall. However, at other frequencies, drywall and plaster construction can sustain the same peak particle velocity, e.g., 2.0 in./s at a frequency greater than 30 Hz. However, the blaster must install seismographs that record both peak particle velocity and frequency for each blast and include this information in the blasting records.

Analysis of Restatement Approach to Nontrespassory Blasting Damages

Restatement §519—General Principle

The Restatement, Second, Torts[81] is frequently used to apply strict tort liability to construction blasting claims because blasting is usually classified as an abnormally dangerous activity using the six factors presented in Restatement §520[82] and possibly the blasting examples presented in the comment for Subsection (2) of Restatement §519. Restatement §519 follows the framework suggested by Prosser[83] and does not differentiate between trespassory and nontrespassory damages.[84] Restatement §519[85] states the following:

> "(1) One who carries on an abnormally dangerous activity is subject to liability for harm to the person, land or chattels of another resulting from the activity, although he has exercised the utmost care to prevent the harm.
>
> (2)This strict liability is limited to the kind of harm, the possibility of which makes the activity abnormally dangerous."

Therefore, if blasting is considered to be an abnormally dangerous activity, the blaster is subject to strict tort liability even though he/she exercised the utmost care, i.e., complied with all applicable blasting guidelines, such as RI 8507 and RI 8485. Comment (d) of Restatement §519[86] also states that liability is not based on intent to do harm to the plaintiff but it is based on the abnormal danger of the activity and the risk that it poses. Thus, a contractor cannot successfully claim a lack of intent to harm as a defense.

Restatement §520—Factors for Determining Abnormally Dangerous Activities

The main issue concerning application of Restatement §519(1)[87] to construction blasting is whether the activity is abnormally dangerous. Restatement §520[88] is used to determine whether an activity is classified as abnormally dangerous and thus subject to strict tort liability using six factors, each of which is discussed below. The following six factors are used by a judge to determine whether or not an activity is abnormally dangerous:

1. Existence of a high degree of risk of some harm to the person, land, or chattels of others.
2. Likelihood that the harm that results from it will be great.
3. Inability to eliminate the risk by the exercise of reasonable care.
4. Extent to which the activity is not a matter of common usage.
5. Inappropriateness of the activity to the place where it is carried on.
6. Extent to which its value to the community is outweighed by its dangerous attributes.

All of the factors are important, but it is not necessary that each of the factors be present, especially if others weigh heavily.[89] The first three factors are interrelated, whereas the last three factors are not.

High Degree of Risk of Some Harm

This factor considers whether there is a high degree of risk of some harm to the person, land, or chattels of others by the activity. Comment (g) of the Restatement states that the harm threat-

Table 3. Damage Classification from U.S. Bureau of Mines RI 8507[100]

Uniform classification	Description of damage
Threshold	Loosening of paint; small plaster cracks at joints between construction elements; lengthening of old cracks
Minor	Loosening and falling of plaster; cracks in masonry around openings near partitions; hairline to 3-mm cracks (0–1/8 in.); fall of loose mortar
Major	Cracks of several millimeters in walls; rupture of opening vaults; structural weakening; fall of masonry, e.g., chimneys; load support ability affected

ened must be "major in degree" and sufficiently serious in its possible consequences to justify strict tort liability.[90] Comment (g) continues "It is not enough that there is a recognizable risk of some relatively slight harm, even though that risk might be sufficient to make the actor's conduct negligent if the utility of his conduct did not outweigh it, or if he did not exercise reasonable care in conducting it."[91]

The three harms that could be major in degree from construction blasting are flyrock, structural damage or collapse, and flying glass from air overpressures. Flyrock can be eliminated by complying with the blasting limits in Tables 1 and 2, and the risk of flyrock can be reduced even further with the use of blasting mats of the blasting area. The levels of vibrations and air overpressure required to cause structural damage or flying glass are not encountered in current construction blasting, especially if the blasting limits in Tables 1 and 2 are followed.[92] The harm, if any, caused by construction blasting will consist of cosmetic cracking with no impact to the structural integrity of the structure. Currently, blasting damage is classified using the classification scheme presented in Table 3. Table 3 shows that threshold damage corresponds to cosmetic damage, e.g., loosening of paint, small plaster cracks, or lengthening of old cracks and not structural damage or collapse. Thus, the onset of harm, i.e., small plaster cracks, is not a harm of "major degree," has no serious implication to the stability of a structure, and does not satisfy the first factor of §520. For example, Scholl (1976) studied 52 cases of alleged nuclear-blast-induced damage in Nevada, and the average damage award to remediate the cosmetic cracking was approximately $400.[93] (A nuclear blast produces similar high frequency vibrations, i.e., between 10 and 100 Hz, as construction blasting, although the magnitude of a nuclear blast can be much greater than construction blasting, whereas earthquake shaking produces frequencies between 0.2 and 2 Hz.) A homeowner probably will be concerned about the resale of the structure with the presence of cosmetic cracking. The cosmetic cracking, if any, can be remediated with routine patching and painting, assuming that similar blasting does not occur again, and thus the resale of the residence should not be harmed. In fact, completion of the construction project may enhance the resale of the property as suggested by the Booth Court.[94]

Finally, all houses have some cracking regardless of the age of the structure.[95] Normal cracking in structures can occur for a variety of reasons, such as environmental forces, design and construction practices, and type of construction material, e.g., wood versus masonry. For example, typical environmental forces that act on a residence and can cause cosmetic cracking include temperature changes and thermal shock, daily weather cycles, and changes in moisture content that can lead to heave or shrinkage of the foundation soils. Expansive soil is a common cause of cracks in a structure or appurtenant structures, such as driveways, walkways, and patios, in a number of areas of the country because of the presence of expansive soils. Expansive soils cause about $9 billion dollars of physical damage each year in the United States, which is more than that incurred in all earthquakes, floods, tornados, and hurricanes combined in an average year (Coduto 2001).[96] Some of the states impacted by expansive soils include Colorado, California, Texas, Arizona, Nevada, Wyoming, North and South Dakota, and Utah (Coduto 2001).[97]

A 1925 publication of the Architect's Small House Service Bureau (1925)[98] discusses cracking in homes and presents 40 common reasons why cosmetic cracks appear in homes. The reasons include poor construction practices, e.g., failure to make foundation footings wide enough, too few nails, placing one end of floor joists on masonry and the other end on wood, and the use of poor construction materials, e.g., insufficient cement in the concrete and dirty sand or gravel in the concrete.[99] Oriard augmented this 1925 list with 20 additional common items causing cosmetic cracks, including (1) defective materials, e.g., use of green lumber, too much water in concrete, plaster, and stucco mixes, and too thin concrete slabs or plaster walls; (2) construction workmanship, e.g., failure to include concrete expansion joints and/or wire mesh in concrete slabs, planting trees or large shrubs too close to the house or other construction, and placing different materials in direct contact with one another without providing for expansion and contraction; and (3) inadequate maintenance, such as failure to keep interior rooms heated during the winter and failure to carry surface runoff from foundations.[100] Therefore, the type of harm that is likely to occur with construction blasting, i.e., cosmetic cracking, is usually already present in a structure or is likely to develop during the life of the structure and not major in degree.

Comment (g) of Restatement §520 states that it is not enough that there is a recognizable risk of slight harm even if the contractor is negligent.[101] In other words, strict tort liability is not applicable if the risk involves a slight harm, e.g., cosmetic cracking, even if the contractor is negligent during the blasting. If the contractor adheres to the blasting limits in Tables 2 and 3, field observations show that the harm, if any, will be cosmetic or slight (Office of Surface Mining 1977).[102]

Likelihood that Resulting Harm Will Be Great

The second abnormally dangerous factor considers the likelihood that the resulting harm from the activity will be great. There is no field evidence of personal injury being caused by ground vibration when the peak particle velocity is less than 2 in./s and the air overpressure is less than 0.0145 psi (134 dB). Employees of the blaster are most susceptible to injury and they are covered by Workers Compensation so compensation for personal injuries is not a concern. Flying debris causes the largest potential for personal injury. If common remedial measures are used, e.g., covering the blast area with blasting mats and limiting the explosives per delay to comply with the limits in Tables 1 and 2, there is little possibility that personal injury will occur due to flyrock. If the blasting limits in Tables 1 and 2 are followed, field measurements and observations of blasting activities also show that the harm, if any, to adjacent structures will be cosmetic.[103] In fact, there is no evidence of cosmetic cracking occurring from construction vibrations at peak particle velocities below 0.8 in./s,[104] and the USBM guidelines in RI 8507 limit the peak particle velocity to 0.75 and 0.5 in./s for drywall and plaster construction, respectively. Therefore, if these limits are followed, even cosmetic cracking will not be an issue.

Inability to Eliminate Risk by Exercise of Due Care

The third abnormally dangerous factor is the inability to eliminate the risk, which Comment (h) cites as "another important factor to be taken into account."[105] The essence of this factor is to evaluate the "unavoidable risk" remaining in the activity after the actor has taken all reasonable precautions.[106] The strict tort liability example in Comment (h) involves the manufacture of explosives in a city, which involves a risk of detonation in spite of the manufacturer's efforts to prevent an explosion during manufacturing.[107] An important difference between this scenario and controlled construction blasting is that an explosion during manufacturing can be uncontrolled and detonate substantially more explosives than intended. In construction blasting, where the size and timing of the blast are strictly controlled to excavate a well-defined area or opening, the impacts are well understood, and precautions can be taken, e.g., evacuating nearby areas. Thus a blast during manufacturing could result in the first three factors of §520 being satisfied and strict tort liability is probably a suitable framework for the manufacturing of explosives in an urban area. However, in construction blasting, only the quantity of explosives that are required for the project is stored on site and in most instances only the quantity needed for a particular segment of the project is stored at a time. This can result in quantities that are substantially smaller than those in explosive manufacturing. In addition, the time of blasting is selected and precautions taken, e.g., stopping vehicle and pedestrian traffic near the construction site and blasting at early morning hours, e.g., 2:30 a.m. in Las Vegas, to reduce the likelihood of any harm.

As described previously, blasting programs can be designed to significantly reduce the risk, primarily by reducing the weight of explosives detonated in each delay. A performance-based specification can be used to set the allowable peak particle velocity and air overpressure that a contractor can induce. In summary, there are many parameters that can be controlled in construction blasting to significantly reduce the risk of damage and thus it is proposed that construction blasting does not satisfy the third factor of §520. An example of how carefully blasting can be controlled in construction blasting is the use of explosives to create the Mt. Rushmore and the Crazy Horse Monuments in South Dakota.

Common Usage of Activity

The fourth abnormally dangerous factor is whether the activity is a matter of common usage. Comment (i) states common usage is "an activity carried on by the great mass of mankind or by many people in the community."[108] Comment (i) uses blasting as an example of a proper means of excavation for building purposes that is not performed by "any large percentage of the population" and thus is not a matter of common usage.[109] Following this logic most, if not all, construction activities are not common usage and thus abnormally dangerous because only a small percentage of the population are contractors. The public benefits of construction in the "building up of towns and cities and the improvement of property"[110] suggest that each construction activity should be evaluated to assess whether or not it is abnormally dangerous. For example, should excavation by a backhoe be an abnormally dangerous activity because it is not in common usage by a large percentage of the population? It is arguable that the use of a backhoe is similar to the use of a car, which is an example in Comment (i). An automobile was initially used on a limited basis and came into general use such that they are now a matter of common usage.[111] Backhoes are now present on most construction sites and frequently travel on public roads without incident.

At present construction blasting is not a common in urban areas but has been used to implode structures in congested areas. The potential liability for blasting encourages/requires a blasting contractor to (1) perform building condition surveys and sometimes place sensors across cracks to measure crack movement[112] before and after construction blasting to document the behavior of existing cracks before and immediately after blasting to discourage unmeritorious claims; (2) measure the ground vibrations and air overpressures in an effort to prove compliance with tolerable limits; and (3) conduct a public relations program about the benefits and necessity of the project and thus the blasting.[113]

Comment (i) does leave open the possibility of blasting being a common usage by stating "Certain activities, notwithstanding their recognizable danger, are so generally carried on as to be regarded as customary."[114] It is possible that imposition of a negligence framework for construction blasting would increase the use of this cost-effective excavation and demolition technique and thus it could become another example of how a risky activity can eventually become a common usage, e.g., aviation, fireworks displays, and discharge of firearms.

Inappropriateness of Location of Activity

The fifth abnormally dangerous factor evaluates the appropriateness of the activity to the place where it is performed. Comment (j) states explosives "capable of destroying everything within a distance of half a mile, does not necessarily create an abnormal danger if it is located in the midst of a desert area, far from human habitation and all property of any considerable value."[115] However, the same blasting operations "become abnormally dangerous if they are carried on in the midst of a city."[116] This factor is sometimes used to apply strict tort liability in the absence of the first three factors. However, this appears to deviate from the purpose of imposing strict tort liability, which is preventing harm that will be great and cannot be eliminated by reasonable care.[117] This leads to the premise that blasting can be conducted in urban areas under a negligence framework if the activity can be performed without creating an abnormal danger or high risk of great harm. The harm, if any, to adjacent structures will be cosmetic damage if the blasting limits in Tables 1 and 2 and typical industry procedures, e.g., use of blasting mats, are followed.

Extent that Value to Community Is Outweighed by Dangerous Attributes

The final abnormally dangerous factor is the extent to which the value of blasting to the community is outweighed by its dangerous attributes. Comment (k) illustrates this factor by stating the following:

> "Even though the activity involves a serious risk of harm that cannot be eliminated with reasonable care and it is

> not a matter of common usage, its value to the community may be such that the danger will not be regarded as an abnormal one."[118]

Because the dangerous attributes of construction blasting can be mitigated, the community value of blasting to facilitate construction and property development should be compared with the potential harm of cosmetic cracking. If the blasting contractor uses reasonable care, e.g., follows current blasting limits shown in Tables 1 and 2, blasting can provide value to a community by allowing excavation or demolition to occur in a more cost-effective manner. The implosion of old casinos and hotels on the Las Vegas Strip is an excellent example of the use of blasting to facilitate redevelopment of prime real estate. Blasting also provides social utility by reducing demolition/excavation costs, accelerating construction, and allowing underground excavation without typical cut and cover operations that disrupt ground surface activities.

If blasting is being conducted for a public works project, e.g., a new water tunnel, subway, or sports stadium, the value to the community may exceed the reduction in property resale value caused by cosmetic cracking. Recent examples of such projects are the use of blasting to implode Three Rivers Stadium in Pittsburgh on February 10, 2001 and Market Square Arena in Indianapolis on July 8, 2001. Both implosions occurred after construction of new facilities and to assist redevelopment of important urban real estate. As older industrial urban areas pursue economic redevelopment, the use of blasting may be more desirable in urban areas. For example, implosion of Memorial Homes Towers in Brunswick, N.J. on 18 August 2001 for construction of new low income housing. This reasoning for public works projects was also suggested by the Booth Court by indicating that if the blasting was conducted under a government contract, it would be another reason to impose a negligence standard.[119]

Analysis of this factor involves a subjective evaluation of the value of a particular activity to a community. Under the strict tort liability framework, the court, not a jury, decides whether an activity is abnormally dangerous. Prosser reinforces this suggestion by stating the following:

> "When a court applies all of the factors suggested in the Second Restatement it is doing virtually the same thing as is done with the negligence concept, except for the fact that it is the function of the court to apply the abnormally dangerous concept to the facts as found by the jury."[120]

If construction blasting were analyzed under a negligence framework, a jury would evaluate the community value of the activity and whether or not the contractor exercised reasonable care in the activity.[121] It is proposed that a jury is better suited for balancing the community value of blasting to construction of a new facility versus the cosmetic nature of the harm. As well, a jury also may facilitate a plaintiff's cause because juries may be more sympathetic to homeowners.

Conclusions

It is proposed herein that construction blasting may no longer be an abnormally dangerous activity based on the six factors presented in Section 520 of the Restatement of the Law of Torts, Second,[122] and thus warrants a negligence, not strict tort liability, legal framework. The analysis of the six factors in §520 of the Restatement, Second, Torts[123] used to determine whether an activity is abnormally dangerous[124] shows that the only factors possibly satisfied to classify construction blasting as abnormally dangerous are the inappropriateness of location and common usage when blasting is conducted in an urban area. The next factor that may result in blasting being classified as abnormally dangerous is the value of blasting to the community. The analysis of this factor probably depends on the nature of the construction project including the question of whether the benefits are public or private. Current blasting technology allows the remaining factors to be controlled and thus these abnormally dangerous factors are not satisfied if the contractor adheres to the standard of care for blasting set forth by USBM and OSM regulations.

The real issue concerning imposition of strict liability to construction blasting in urban areas is whether the risk created is so unusual, either because of its magnitude or because of the circumstances surrounding it, as to justify the imposition of strict tort liability for the resulting harm regardless of the level of care.[125] Based on current blasting technology, the risk of building damage caused by ground vibrations and air overpressures is not so "unusual" if the blasting limits in Tables 1 and 2 are followed. If the contractor does not use current blasting technology, a claim of negligence could be used to assess liability to the contractor as was done in New York prior to imposition of strict tort liability in the Spano case.[126] Thus, it is proposed that blasting advances in the past 40 years has allowed construction blasting to join aviation, fireworks displays, and discharge of firearms as not an abnormally dangerous activity. Thus, the question of this paper: Is construction blasting still abnormally dangerous?

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Armstrong v. City of Cincinnati, 22 Ohio C.D. 714 (1909).
Ballard v. Buckley Powder Co., 60 F.Supp.2d 1180 (D.Kan. 1999).
Booth v. Rome, Watertown and Ogden Terminal Railroad Company, 140 N.Y. 267 (1893).
Burgan v. City of Pittsburgh, 542 A.2d 583 (1988).
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Spano v. Perini Corp., 250 N.E.2d 31 (N.Y. 1969).
Trinity v. Crosby, 112 Vt. 95 (1941).
Watson v. Mississippi River Power Co., 156 N.W. 188, 191 (1916).

List of Statutes

225 Illinois Compiled Statutes 715—Surface-Mined Land Conservation and Reclamation Act (Source: P.A. 86-1475).

Endnotes

[1]Spano v. Perini Corp., 250 N.E.2d 31, 31 (N.Y. 1969).
[2]56 ALR3d 1017,1020, Blasting-Indirect Injury or Damage.

[3]56 ALR3d 1017,1020.
[4]Watson v. Mississippi River Power Co., 156 N.W. 188, 191 (1916).
[5]Prosser, W. L., The Law of Torts, 5th ed., Hornbook Series, West Publishing Co., St. Paul, MN, §78 (1984) at 553.
[6]Restatement, Torts 2d §520, 36, Vol. 3, 1997, The American Law Institute, Philadelphia.
[7]Dowding, C. H. *Construction Vibrations*, Prentice Hall, Upper Saddle River, NY, 604 p. (1996) at 459.
[8]Siskind, D. E., Vibrations from Blasting, International Society of Explosives Engineers, Cleveland, OH, 120 p. (2000) at ix.
[9]Armstrong v. City of Cincinnati, 22 Ohio C.D. 714 (1909).
[10]Reynolds v. W.H. Hinman Co., 75 A.2d 802 (Me. 1950).
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[15]Trinity v. Crosby, 112 Vt. 95 (1941).
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[21]Oriard, L. L., *The Effects of Vibrations and Environmental Forces: A Guide for the Investigation of Structures*, Monograph published by International Society of Explosives Engineers, Cleveland, Ohio, 284 p. (1999), 1.
[22]Oriard 1999 at 1.
[23]Oriard 1999 at 3.
[24]Oriard 1999 at 4.
[25]Oriard 1999 at 4.
[26]Ballard v. Buckley Powder Co., 60 F.Supp.2d 1180 (D.Kan. 1999).
[27]Ballard at 1182.
[28]Ballard at 1182.
[29]Ballard at 1182.
[30]Spano v. Perini Corp., 250 N.E.2d 31 (N.Y. 1969).
[31]Booth v. Rome, Watertown and Ogden Terminal Railroad Company, 140 N.Y. 267 (1893).
[32]Booth at 267.
[33]Booth at 267.
[34]Booth at 267.
[35]Absolute liability jurisdictions in 1969 include California, Colorado, Connecticut, Delaware, Georgia, Hawaii, Illinois, Indiana, Iowa, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Washington, West Virginia, and Wisconsin.
[36]Negligence jurisdictions in 1969 include Alabama, Arizona, Arkansas, Kansas, Kentucky, Maine, Maryland, Massachusetts, New York, Texas, and Virginia.
[37]Spano at 32.
[38]Spano at 33.
[39]Spano at 33.
[40]Spano at 33.
[41]Spano at 35.
[42]Spano at 35.
[43]Spano at 33.
[44]Spano at 33.
[45]Spano at 33.
[46]Spano at 33.
[47]Spano at 35.
[48]Spano at 35.
[49]Oriard 1999 at 2.
[50]Siskind at 1.
[51]Siskind at 1.
[52]Siskind, D. E., Stagg, M. S., Kopp, J. W., and Dowding, C. H., Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting, U.S. Bureau of Mines, RI 8507, 74 p. (1980a).
[53]Siskind, D. E., Stachura, V. J., Stagg, M. S., and Kopp, J. W., Structure Response and Damage Produced by Airblast from Surface Mining, U.S. Bureau of Mines, RI 8485, 111 p. (1980b).
[54]Siskind et al. (1980b).
[55]Dowding at 437.
[56]Dowding at 437.
[57]Dowding at 4.
[58]Dowding at 4.
[59]Dowding at 5.
[60]Dowding at 5.
[61]Office of Surface Mining Reclamation and Enforcement, Surface Coal Mining and Reclamation Operations; Initial and Permanent Regulatory Programs; Use of Explosives. Federal Register, v. 48, No. 46, Section 816.67(d)(2), March 8 (1983), pp. 9788–9811.
[62]225 ILCS 715.
[63]Oriard at 27.
[64]Siskind (2000) at 20.
[65]Duvall, W. I., Johnson, C. E., Meyer, A. V. C., and Devine, J. F., Vibrations from Instantaneous and Millisecond-Delayed Quarry Blasts, U.S. Bureau of Mines, RI 6151, 34 p. (1963).
[66]Siskind (2000) at 20.
[67]Siskind (2000) at 20.
[68]Siskind (2000) at 20.
[69]Siskind (2000) at 25.
[70]Dowding at 45.
[71]Dowding at 45.
[72]Spano at 31.
[73]Spano at 32.
[74]Spano at 32.
[75]Spano at 35.
[76]Spano at 35.
[77]Office of Surface Mining Reclamation and Enforcement, Surface Coal Mining and Reclamation Operations; Initial and Permanent Regulatory Programs; Use of Explosives. Federal Register, v. 48, No. 46, Section 816.67(d)(2), March 8 (1983), pp. 9788–9811.
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[79]Oriard at 27.
[80]Office of Surface Mining Reclamation and Enforcement, Surface Coal Mining and Reclamation Operations; Initial and Permanent Regulatory Programs; Use of Explosives. Federal Register, v. 48, No. 46, Section 816.67(b)(1), March 8 (1983), pp. 9788–9811.
[81]Restatement, Torts 2d §519, 34.
[82]Restatement, Torts 2d §520, 36.
[83]Prosser, W. L., The Law of Torts, 2d ed., Hornbook Series, West Publishing Co., St. Paul, MN, §59 (1955) at 336.
[84]Prosser (1955) at 336.
[85]Restatement, Torts 2d §519, 34.

[86]Restatement, Torts 2d §519, 35.
[87]Restatement, Torts 2d §519, 34.
[88]Restatement, Torts 2d §519, 34.
[89]Restatement, Torts 2d §519, 34.
[90]Restatement, Torts 2d §520, Comment (g), 38.
[91]Restatement, Torts 2d §520, Comment (g), 38.
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[93]Scholl, R. E., "Low Rise Building Damage from Low Amplitude Ground Motions," Proceedings of 2nd Conference on Explosives and Blasting Techniques, Society of Explosives Engineers, Cleveland, OH, pp. 51–66 (1976).
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[98]Architect's Small House Service Bureau, "The Small Home: Forty Reasons Why Walls and Ceiling Crack," Vol. 4, No. 8 (1925).
[99]Oriard at 73.
[100]Oriard at 74.
[101]Restatement, Torts 2d §520, Comment g, 38.
[102]Office of Surface Mining, "Surface Mining Reclamation and Enforcement Provisions," Public Law 95-87, Federal Register, Vol. 42, No. 289 (1977).
[103]Oriard at 227.
[104]Dowding, C. H., "Measure the Crack Instead of Construction Vibrations," Geo-Strata, American Society of Civil Engineers, Reston, VA, 20–23 (2001), 20.
[105]Restatement, Torts 2d §520, Comment (h), 38.
[106]Restatement, Torts 2d §520, Comment (h), 38.
[107]Restatement, Torts 2d §520, Comment (h), 38.
[108]Restatement, Torts 2d §520, Comment (i), 39.
[109]Restatement, Torts 2d §520, Comment (i), 39.
[110]Booth at 281.
[111]Restatement, Torts 2d §520, Comment (i), 39.
[112]Dowding, C. H., "Measure the Crack Instead of Construction Vibrations," Geo-Strata, American Society of Civil Engineers, Reston, VA, 20–23 (2001), 20.
[113]Dowding (2001) at 20.
[114]Dowding (2001) at 40.
[115]Restatement, Torts 2d §520, Comment (j), 41.
[116]Restatement, Torts 2d §520, Comment (j), 41.
[117]Prosser, W. L., The Law of Torts, 4th ed., Hornbook Series, West Publishing Co., St. Paul, MN, §78 (1984) at 555.
[118]Restatement, Torts 2d §520, comment (j), 41.
[119]Booth at 279.
[120]Prosser (1984) at 555.
[121]Restatement, Torts 2d §520, comment (l), 42.
[122]Restatement, Torts 2d §520.
[123]Restatement, Torts 2d §520.
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[126]Spano at 31.

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