Pest Prevention by Design

Authoritative guidelines for designing pests out of structures

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Authoritative Guidelines for Designing Pests Out of Structures

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In addition to our historic function of providing environmental policy direction for the Mayor and Board of Supervisors, SF Environment delivers service programs for San Francisco residents and businesses including recycling, toxics reduction, environmental justice grants, and energy efficiency. See www.sfenvironment.org

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The International Code Council is a member-focused association dedicated to helping the building safety community and construction industry provide safe, sustainable and affordable construction through the development of codes and standards used in the design, build and compliance process. Most U.S. communities and many global markets choose the International Codes. ICC Evaluation Service (ICC-ES), a subsidiary of the International Code Council, has been the industry leader in performing technical evaluations for code compliance fostering safe and sustainable design and construction.

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Pest Prevention by Design – Technical Advisory Committee

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Revision History

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November 5, 2012	Revision for second review by ICC
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Background

The world is blessed with many charming, pleasurable, glamorous and enticing subjects on which to ponder. Pest management is not one of these.

In fact, the case could be made that the average human actively avoids the subject, and with good reason. Pests are defined, after all, as organisms that humans do not want around[1]. They are organisms that compete with us for resources, carry diseases, create unsafe conditions, or merely offend our aesthetics. In our minds (and sometimes in reality) pests are vile, repellent, creatures that may symbolize poor sanitation, dilapidation and neglect. We recoil at the sight of a mouse under the refrigerator or a cockroach in the pantry. At cocktail parties they make profoundly poor conversation starters.

It is no wonder, then, that when faced with pest infestations, or the prospect of future infestations, our response is less than thoughtful. We want them dead, and quickly. We prefer a simple, effective solution to our pest problems – a silver bullet - so that we can move on to more appetizing topics. Our measure of success is quick action and maybe a few carcasses.

Agricultural ecologists realized decades ago the fallacy of this simplistic approach to managing complex biological systems, as described by Prof. Robert Van Den Bosch in his classic *The Pesticide Conspiracy*[2]. Farmers soon realized that the silver bullet promised by DDT and other new pesticides could not last: Pests became resistant to the chemicals, requiring greater and greater amounts for the same effect; natural predators were decimated by the pesticides, resulting in even more extreme outbreaks of pests, and insects that had never been pests before were unleashed to create new problems, without the natural regulation of predators and parasitoids. In addition, by depending solely on chemicals and not addressing the root causes of problems – such as stressed plants, depleted soils or poor plant varieties – the conditions remained optimal for pest resurgences.

In response to these problems, scientists developed integrated pest management (IPM), a decision-making process that emphasizes prevention, knowledge of pest biology, and the use of least-disruptive control tactics, with pesticides saved as a last resort [3]. While IPM has become standard practice in agriculture, it has been slower to take hold for structural pest management. Successful pest management on the farm can be measured easily at harvest time through crop yields and quality, but this is not the case in the city. Here success is more subjective, even psychological.

Homeowners may feel successful if they see dead ants on the floor, not knowing that their spray can has made no impact on the health of the ant colony. Still farther from their thoughts are the forgotten food scraps beneath the refrigerator that attracted the ants in the first place, or the scale insects living on the fruit tree just outside, whose sugary droppings help boost the colony's population.

A restaurant owner facing a rat infestation wants the evidence destroyed before the next health department inspection. However, she may not consider sealing the gap in the door frame that let the animals enter in the first place, or putting a better lid on the dumpster out back, or removing the English ivy patch in the backyard (a preferred rat habitat). The result of our short-sighted approaches to this somewhat repulsive topic is that pests are managed neither safely, nor effectively, nor economically. Too often we ignore the most important, logical and environmentally sound step—*prevention*.

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[1] Sutherst 1995; Maine School IPM Program 2005
[2] Van den Bosch 1978
[3] Flint et al 200

The Problem

Prevention of pest problems is the heart of any state-of-art integrated pest management programs, and the subject of these guidelines. Pest proofing in conjunction with sanitation efforts provides the best long-term management of urban pest infestations[4]. Relatively simple design features can substantially reduce long-term pest control costs in buildings and landscapes, while also cutting the health and environmental impacts of pesticide use[5].

Examples of pest preventative building/retrofit techniques are scattered through the scientific literature[6] Many other techniques, often based on years of experience or anecdotal evidence, can be found in the pest control industry journals[7], handbooks[8], and in various guidelines issued by public agencies[9].

However, pest preventive tactics are rarely included *comprehensively* at the design stage of buildings. While various lists of these tactics have been compiled[10], most have been piecemeal and none have been subjected to rigorous review. The specialized and often insular nature of the architectural, construction, facility management, and pest control industries further obstructs progress. What information is available is not targeted for those who need it most: The architects, engineers and builders who actually create the built environment.

Building codes generally require some of the more common procedures, such as a screening foundation vents[11]. Other objectives, such as moisture reduction, have found their way into generally accepted best construction practices[12]. Experienced pest control professionals understand many of the prevention approaches, although they may not have occasion to put them into practice due to prevailing business models emphasizing treatment rather than prevention.

The recent explosion of interest in Green Building standards, such as the Leadership in Energy and Environmental Design (LEED) program[13] and the International Green Construction Code (IgCC)[14] provides new opportunities for integrating pest prevention into a holistic design framework. Although LEED credits are available for IPM, no reference standards for pest prevention features yet exist for LEED. The same can be said for other common green building frameworks such as the National Association of Homebuilders NAHBGreen/ICC 700 and the Build It Green programs.

Many of the principles presented here require architects and builders to rethink their design strategies in a more holistic fashion. This rethinking is needed both for established design approaches, such as the standard acoustical gaps in ceilings that can also serve as rodent or cockroach hotels, and emerging approaches, such as the promotion of living walls that will have unknown impacts on pest infestations. In other examples, tactics for designing out pests will likely harmonize very well with the sealing and weatherization tactics needed to conserve energy.

Clearly, an opportunity exists to both provide definitive design guidelines for pest prevention, to incorporate these guidelines into existing design frameworks, and in the end to reduce long-term costs and pesticide use in the built environment. Thus the goal for this publication: *To create a set of authoritative, peer-reviewed guidelines for designing and building pests out of buildings*.

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[4] Scott, 1991
[5] Brenner et al, 2003
[6] Ebeling, 1978; Mallis, 1997; Smith and Whitman 2007; Lewis 1997, 2003; Global Termite Expert Group for the United Nations Environmental Programs; http://www.chem.unep.ch/pops/termites/termite_toc.htm, Pratt 1949; Frantz 1988; Scott 1991
[7] For example, Pest Control Technology Journal, http://www.pctonline.com/
[8] Smith and Whitman, 2007
[9] Armed Forces Pest Management Board, 2009
[10] Simmons, 2010
[11] International Code Council, 2012 F101.1
[12] Newport Partners LLC, 2006
[13] http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988
[14] www.iccsafe.org

History of the Project

The idea for these guidelines began in 2005, when the San Francisco's IPM Program collectively realized that the City had stopped making real progress in pesticide use reduction on its properties. Pesticide use had declined by 80% in the first eight years of the program, but seemed to have bottomed out. After extensive consultations with field staff, we concluded that fundamental design problems in both buildings and landscapes were partly to blame. Deferred maintenance on structures allowed rodents and cockroaches easy entry, while poor landscape designs exacerbated weed problems. Having gone as far as we could to restrict hazardous pesticides and promote least-toxic treatment strategies, it was time to better address pest prevention. At a daylong stakeholder event in 2009, IPM Program participants reached the same conclusion, and committed the program to emphasize prevention in both its landscape and structural IPM activities. The idea for an authoritative set of guidelines on the subject was further fleshed out at the 2009 National IPM Symposium in Portland, Oregon. After two years of grant writing, funding was finally received from the US Centers for Disease Control as part of San Francisco's REACH grant.

Methods

The San Francisco Department of the Environment organized the Pest Prevention By Design Technical Advisory Committee (PPBD TAC) in the Spring of 2011. Since the subject matter is highly interdisciplinary, committee members were sought from a variety of sectors: Pest control professionals, architects, engineers, pest management researchers/academics, green building experts, IPM experts/consultants, and public agencies.

At the same time, the Department undertook a comprehensive literature review on the subject. This review included scientific literature, manuals, websites, and professional publications. A web-enabled database was developed to organize the resulting list of pest prevention tactics. The database was also designed to track references, individual ratings and comments submitted by Committee members, and a variety of other details. Variables included in the database were:

- **Tactic Summary**
- **Description of Tactic**
- **Building area category** (kitchens, foundations, exterior shell, etc.)
- **Sources of Information**
- **Files, photos or videos**
- **Tactic used at design vs. retrofit stage**
- **Pests affected** (Birds, ants, bedbugs, cockroaches, fleas, flies, mosquitoes, wasps & bees, dampwood termites, Formosan termites, drywood termites, subterranean termites, miscellaneous wood-destroying insects, miscellaneous insects, spiders, mice, rats, opossums & raccoons, miscellaneous mammals.)
- **Regions affected** (East North Central, Central, Northeast, Northwest, South, Southeast, Southwest, West, West North Central)
- **Scientific ratings of effectiveness**
- **Anecdotal ratings of effectiveness**
- **Anecdotal evidence**
- **General comments**
- **Compatibility with other design goals** (for example, likely conflicts or synergies of particular tactics with energy efficiency or aesthetic goals)
- **Relevant tools and products**
- **Facilities type** (institutional, residential, or all)

The Center for Environmental Health was contracted to coordinate the PPBD development effort. The first official meeting of the PPBD TAC was held in June, 2011, and the Committee met monthly 12 times in the following year. At each meeting, the Committee discussed a new batch of pest prevention tactics.[15] Feedback from the web tool and from the meetings themselves was incorporated into the draft guidelines. The project also contracted with the International Code Council to review all of the guidelines in detail before publication, and to identify any clear redundancies with accepted building practices and building codes. A pest-proofing and IPM pilot project was initiated on San Francisco Housing Authority properties to obtain data on costs and benefits of pest prevention retrofits.

How to Use These Guidelines

This publication is intended for architects, engineers and builders who wish to take green building to the next level, but can be used by anyone who wishes to incorporate well-informed design choices into the design and retrofit of buildings. We undertook the project to fill a glaring gap in the pest management world: To our knowledge, no other comprehensive guidelines on pest preventive design tactics exist.

Pest prevention is a broad subject, and we had to draw some boundaries. It is worth reminding the reader of the scope and limitations of this document. To make best use of these guidelines, the user should understand what these guidelines are and are not.

Structural emphasis. The PPBD Technical Advisory Committee decided early on that this resource should best focus on pest prevention in structures. Prevention of pests in landscapes – while important and similarly underaddressed – was intentionally excluded from this volume. The only exceptions are cases where landscape features adjacent to structures affect pest infestations inside the structures themselves. For example, several species of ivy, including the common English ivy (Hedera helix) as well as other common ground covers such as Pachysandra and Liriope spp., are known to provide an ideal habitat for rats, and plantings adjacent to buildings dramatically increase the chance of rat infestations.

Guidelines, not standards. Best practices vary widely depending on the purpose of the building, its location, prevailing pests, climate, and the relative importance of sometimes-competing goals such as construction cost, energy conservation or aesthetics. For this reason, we present these pest prevention tactics as guidelines, not rules or standards. In some cases, we have listed instances where a tactic is likely to conflict with other design goals, such as energy conservation or aesthetics.

North American emphasis. We emphasize North American pests and building practices, although many of the tactics listed could be applied anywhere. When appropriate we have labeled specific tactics that may be more appropriate for certain regions; for example, builders in the Southern states face higher termite pressures and should pay closer attention to features such as separation between soil and wood, termite barriers beneath foundations, and avoidance of stucco construction.

Key to the Guidelines

- **Tactics are organized by building area category**
  For example, kitchens, exterior shell and foundations. A set of general principles are also provided.
- **Information sources:**
  We have provided references to scientific literature when possible. Lacking that, we provide references to professional literature or websites. Some tactics were suggested by the PPBD Technical Advisory Committee during our discussions; these are labeled as Technical Advisory Committee comments.
- **Compatibility with other design goals:** In this space we note any known potential conflicts with other design goals, or code sections that are closely related.

[15] Many of the discussions were quite lively: As one committee member commented, this project sometimes became as much an exercise in cross-disciplinary communication as a traditional research project.

Design and retrofit emphasis. These guidelines include features that can be incorporated at either the design stage of a new building, or during a retrofit of existing buildings. In many cases, the tactics can apply to either. We have purposefully excluded routine building management or maintenance activities from the guidelines, even though they may be important components of integrated pest management programs. For example, while regular cleaning of refuse containers may be an effective preventive tactic for flies, is not included because it would be considered part of routine sanitation – not a design feature. Similarly, we specifically excluded pest control activities, such as wall void treatments with boric acid dusts or installation of bug zappers. We felt that these strategies are expertly addressed by other publications, and are predominantly in the realm of pest control professionals, not builders.

References for more detailed information. Certain facilities, such as food processing or pharmaceutical manufacturing facilities, require pest exclusion specifications that are more detailed than we have provided here. Engineers and architects involved in such projects are referred to Imholte and Imholte-Taushcher (1999).

Although these guidelines are organized by building area, there are some principles that apply throughout. Animals of all kinds, whether vertebrate or invertebrate, are living organisms with biological needs and behavioral preferences. All require FOOD, WATER, HARBORAGE, and ENTRY in order to take up residence and become pests[16]. All of the pest prevention tactics listed herein are based on minimizing these factors. Sometimes, eliminating just one of these factors can be sufficient to prevent infestations.

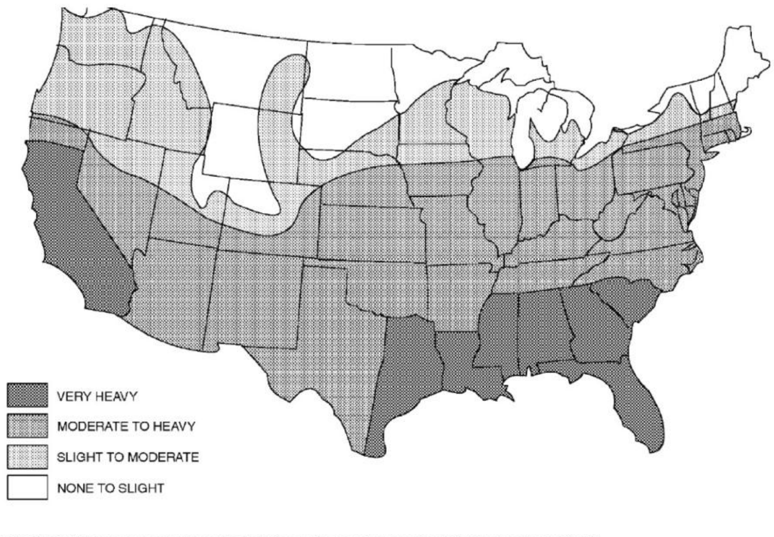
Principle #1: Understand local pest pressures.

Architects, builders and engineers need not be entomologists or pest experts, but a rough familiarly with local structural pest species is essential in order to make the best design choices. University extension services or reputable local pest professionals are the best sources for this information.

Climatic factors limit the distribution of many pest organisms. For example, ants, some cockroaches, termites, rats, mice, birds, and urban wildlife species are all strongly affected by climate. Generally speaking, insect pests are most troublesome in warm, humid climates. Warm temperatures speed up insects' life cycle, resulting in higher populations [17]

The distribution of certain termite species is especially important, since termite pressure has a bearing on many design and materials choices. The International Residential Building Code map of termite problems (Figure 1) is a good place to start.

Figure 1. International Residential Building Code map of termite problems.



Source: International Code Council, 2012 International Residential Code For One- And Two- Family Dwellings Figure R301.2

[16] Purdue University Entomology Extension 2000-2001

[17] Below a lower temperature threshold and above a higher temperature threshold, insects cannot develop (Shelford 1931). In between the two extremes, insect development rates increase with warmer temperatures. As development rates increase, the time to reproductive maturity decreases. For example, German cockroaches show a preference for areas that are at least 70°F (21°C). At this temperature it takes about 100 days for a cockroach to grow from an egg to a mature adult, but at 80°F (27°C) only 60 days are required. (Smith and Whitman 2007 4.9) Argentine ants can take as little as 30 days to develop from egg to adult, or as many as 140. (Smith and Whitman 2007 1.3)

Table1. Summary of common termite species in the United States and their distribution

Common and species name	Geographic distribution
Reticulitermes spp. (subterranean)	Throughout the US except Alaska, with highest populations in the Gulf and Southeastern states
Heterotermes spp. (subterranean)	South Florida and the desert Southwest
Formosan termite, *Coptotermes formosanus* (subterranean)	Southeastern US and Southwestern California
Southeastern drywood termite, *Incisitermes snyderi*	Southeastern US
Western drywood termite, *Incisitermes minor*	Central Arizona west to California and north to Washington State
West Indian drywood termite, *Cryptotermes brevis*	Hawaii, Florida and west to Louisiana
Desert drywood termite, *Marginutermes hubbardi*	Desert regions of southeastern California and Arizona
Dampwood termites, Zootermopsis, *Paraneotermes, Prorhinotermes* spp.	Southern Florida

Source: Univ. of Florida IFAS Extension 2009, Potter 1997

Principle #2: Analyze the physical context for each building situation.

Along with climatic factors, the physical context of a particular building can also be a critical design consideration; that is, the surrounding buildings, surfaces, vegetation, and underground utilities. A building constructed in Manhattan, for example, automatically faces high potential rat infestations[18] due to the intricate tangle of subway tunnels, sewers, and utilities underlying that dense city, as well as the current practice of collecting refuse in plastic garbage bags rather than dumpsters. For such a situation, architects must pay special attention to excluding rats by sealing off all possible entries from the outside. Similarly, buildings constructed near major urban squares – subject to high litter loads from visitors and the occasional dedicated pigeon-feeder – are apt to become prime roosting places for pigeons. Such infestations might be avoided by designing out semi-enclosed alcoves, flat ledges, and other preferred roosting locations[19]. Finally, more rural or suburban locations with dense vegetation (especially carpet-style ground covers and climbing vines) are likely to experience intrusions from a variety of small mammals, such as rats, mice, chipmunks, ground squirrels, raccoons, opossums, and tree squirrels. In these situations, careful attention to screening all gaps from the foundation to the roof vents is strongly advised[20].

[18] Associated Press 2010
[19] University of Florida 2008
[20] Hygnstrom et al., 1994

Principle #3: Design for the necessary pest tolerance level.

An occasional trail of ants in the home may be a mere nuisance, but even a single ant in a surgical ward can have grave consequences. The tolerance to pest infestations varies, and ideally should be considered at the design stage. Institutional kitchens, health care facilities, and mission-critical manufacturing facilities demand detailed and careful design and planning to exclude potential pests[21].

Principle #4: Use durable pest-resistant materials.

Selecting pest-resistant materials can exclude pests from entering a structure, or deny pests harborage once they are there. Some materials provide "resistance to pests" while other materials provide 100 percent exclusion. Selecting materials carefully based on factual information is essential for building engineers, designers and builders.

Many ineffective approaches exist in the pest control world. For example, using spray can foams alone—without the inclusion of impervious stainless steel or copper wool—is one of the worst techniques for excluding rodents from buildings, yet the approach is very common among building superintendents as well as homeowners.

The pest resistance of particular materials also depends on the species of pest in question. Termites, for example, are known to avoid certain woods. Besides being generally more durable than other woods, western red cedar, redwood, and incense cedar, Port Orford cedar, black locust, northern white cedar, and Alaska cedar are known to dissuade termite infestations[22]. Using these woods makes infestation less likely but does not guarantee that infestations will not occur. It is also important to note that only the heartwood from these species is resistant.

Pressure treated woods are widely used for construction uses that involve soil-wood contact or exposure to moisture. There is a wide range of treatments now available, most of which involve chemicals that have environmental or human toxicity issues. For example, chromate copper arsenate (CCA) treatments pose cancer and reproductive hazards to workers and the public, while compounds with high copper content (such as amine copper quat, ACQ) pose higher aquatic toxicity hazards.[23] Borate treatments are viable alternatives for interior use, or situations with low exposure to moisture, which can leach the material out of the wood. New products using silicates also appear promising[24]. In some situations, pressure treated woods remain the most economical choice, but like other woods their resistance erodes with time.

For some applications, such as siding, non-wood alternatives are available that are impervious to insect entry, if not rodents. Fiber cement, aluminum and steel can be appropriate choices for siding in some situations. Stucco, while resistant to insect penetration from the outside, is generally a poor choice in high termite pressure areas for two reasons: Improperly constructed, moisture can accumulate in the enclosed wood, and the stucco shell makes inspection virtually impossible. Some materials such as high density plastic will deter gnawing by rats and mice, and neither rodents nor insect pests are likely to penetrate high quality elastomeric sealant compounds when applied correctly. Recent research[25] has shown that the formidable burrowing Norway rat can be completely deterred from burrowing into soil via the use of a stainless steel mesh carpeting material. Further examples are listed in the tactics section of these guidelines.

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[21] Imholte, et al., 1999
[22] Scheffer and Morrell, 1998
[23] Dickey, 2003
[24] Review of TimberSil, GreenSpec database at http://www.buildinggreen.com/auth/productDetail.cfm?productID=2743 (BuildingGreen.com)
[25] R. Corrigan, pers. communic., 2012.

Principle #5: Design for easy inspection.

"What you don't know won't hurt you" is a shaky philosophy at best, and certainly does not apply to effective pest management. Hidden drains or inaccessible utility boxes can thwart pest control efforts in institutional kitchens, coved baseboards can provide hiding places for bedbugs, ants or small flies, and inaccessible foundations or deck supports can mask termite infestations. Built-in access to critical areas, such as foundations, false ceilings, or triple wall voids, greatly assists pest control professionals in the early detection of wood-boring insects or rodent infestations, potentially saving thousands of dollars in wood replacement and protecting the health of building inhabitants. Lack of easy inspection options can result in increased pest control costs over the life of the building, higher use of pesticides, and greater health and environmental impacts.

Principle #6: Minimize moisture.

All competent builders and architects know that moisture must be excluded from buildings, and many common building codes are aimed at this goal. In addition to promoting building decay, moisture also promotes serious problems with insect pests such as termites, wood-boring beetles, cockroaches, flies, carpenter ants, silverfish, and millipedes, to name but a few. Perhaps even more important, excessive moisture inside buildings can lead to serious mold contamination issues—some of which can require many thousands of dollars in remediation. Multiple procedures can be used to minimize building moisture including proper guttering, downspout placement, correct ventilation of crawl spaces, one-piece countertops, humidistats, vapor barriers for crawl space flooring, appropriate slopes for patios and so forth.

Principle #7: Seal off openings.

Most building codes require that certain intentional openings, such as crawl-space and soffit vents, remain screened to exclude rodents and other wildlife pests. However, effectively sealing off *all* openings to the building exterior, as well as openings between interior rooms, improves the odds of maintaining a pest-free environment.

Elastomeric sealant can be an indispensable tool in sealing small cracks, gaps around countertops, or pipe breaks against insect entry; stainless steel wool and fire block foam can be used for larger openings. The use of escutcheon plates around all pipes where they enter through walls is essential. Foundation expansion joints can be further safeguarded against termites with stainless steel mesh. Doors with minimal gaps, including functioning door sweeps where necessary, and tight fitting windows are also important exclusion features[26].

Many designers are surprised to learn just how small a gap pests can penetrate. For example, the width of a pencil (about ¼") is sufficient to allow mice to squeeze under doors. For convenience, we have provided a table of gap sizes required by various pest species in Table 2 below.

[26] Weather-stripping a door is not equivalent to "pest proofing" a door. High density pest brushes or other door sweeps are critically important.

Table 2. Summary of maximum gap sizes for excluding various pests

	Common Name	Scientific name	Maximum opening size/mesh size	Reference
Insects/arthropods	**Biting midges**	Ceratopogonidae	0.605 mm ~30 mesh	AFPMB, 2009
	Cheese skipper	*Piophila casei*	0.595 mm ~32 mesh	Ebeling, 1975*
	Cockroaches	*Blatella germanica*	1.66 mm ~12 mesh	Koehler, 1994**
	Cotton aphid	*Aphis gossypii*	0.341 mm ~50 mesh	Bethke & Paine, 1991*
	Fruit flies	*Drosophilida* spp.	2.12 mm ~10 mesh	NPS, 2006
	Honeybees	*Apis* spp.	3.00 mm ~7 mesh	NPS, 2006
	House flies	*Musca domestica*	2.03 mm ~10 mesh	Block, 1946
	Mosquito	*Aedes egyptii*	1.03 mm ~18 mesh	Wesley & Morrill, 1956; Block, 1946
	Mosquito	*Anopheles quadrimaculatus, Culex quinquefasciatus*	1.38 mm ~14 mesh	Block, 1946
	Redlegged ham beetle	*Necrobia rufipes*	0.595 mm ~32 mesh	Ebeling, 1975*
	Sand flies	*Phlebotominae* spp. (Psychodidae)	0.605 mm ~30 mesh	AFPMB, 2009
	Termites (Eastern subterranean)	*Reticulitermes flavipes*	0.610 mm ~30 mesh	Tucker, 2008*
	Termites (Formosan)	*Coptotermes formosanus*	0.660 mm ~28 mesh	Grace et al, 1996*
	Thrips	*Frankiniella occidentalis*	0.192 mm ~80 mesh	Bethke & Paine, 1991*
	Yellowjackets	*Vespidae* spp.	3.00 mm ~7 mesh	NPS, 2006
	Scorpions	Scorpionida spp.	1.6 mm	Timm & Marsh, 1997
Birds	**Pigeons**	*Columba livia*	50.8 mm (2 in)	Timm & Marsh, 1997
	Sparrows, Starlings	*Passer* spp., Sturnus vulgaris	19.1 mm (0.75 in)	Timm & Marsh, 1997
Mammals	**Bats**	*Chiroptera spp*	6 mm/0.25 in	Greenhall & Frantz, 1994
	Mice	*Mus musculus*	6 mm/0.25 in	Greenhall & Frantz, 1994
	Rats	*Rattus norvegicus, R. rattus*	9.5mm/3/8 in gaps under doors; 18 gauge 13 mm/0.5 in mesh	Corrigan, 1997

*Studies marked with an asterisk identified nominal gap sizes; these were matched with the closest Tyler mesh size. All other studies referred specifically to minimum mesh sizes; these were matched with approximate gaps sizes. Mesh opening sizes are nominal, i.e., not diagonal.

**Study pertained to preferred harborage for nymphs, not minimum opening for access, which is likely smaller.

Principle #8: Eliminate potential harborage.

Pests need a place to live, preferably a hidden space where they will not be disturbed. Minimizing inaccessible spaces can therefore assist pest management efforts: False ceilings, false bottoms under cabinetry, uncapped concrete blocks, air plenums, and gaps behind permanent machinery are examples. In some cases, the material itself creates a potential harborage, as is the case when rigid foam insulation is used on the outside of foundations – where termites can burrow in and take up residence. Incorporating some of these measures will be simple, while others (such as eliminating air plenums or rigid foam insulation) may directly conflict with other building goals.

Principle #9: Engineer slabs and foundations to minimize pest entry.

The design of foundations and slabs is critical in pest prevention practices and affects a wide range of pests, including ants, termites, mice, rats, and cockroaches. Termites, in particular, will have easy access to those structures with defective foundations or slabs with improper expansion joints. Sufficient separation between the soil and a structure's wooden elements is required by most building codes to inhibit subterranean termite incursions. In addition, architects and builders must minimize concrete cracks that can allow entry of termites or other pests. A variety of tactics can achieve this goal, including the use of appropriate concrete admixtures, monolithic pours, minimization of expansion joints, use of termite-resistant mesh over joints, and the use of termite resistant barriers beneath the slab. In areas with high rodent pressure, curtain walls beneath the foundation of conventional style buildings (i.e., buildings with crawl spaces, not basements) are very helpful.

Principle #10: Design buildings to be unattractive to pests.

What makes a building "attractive" to pests, other than food, water, and potential harborage? Excessive or poorly designed exterior lighting can attract hordes of night flying insects to doorways, windows, or exterior hallways. Roof rats, mice and squirrels find vines up the side of a building to be attractive highways and even food sources. Bushes and shrubs planted too close to building foundations become pest magnets, offering near-ideal concealment and protection from the elements. Trees placed too close to buildings will eventually have limbs touching roofs and walls, which may become pest conduits. Poorly placed composting operations or refuse bins can similarly attract rodents to the environs of a structure, making entry that much more likely. Semi-enclosed, horizontal roof surfaces, especially near outdoor eating areas, are invitations for pigeons.

Acknowledgements

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Principle 1.1 Drainage design.

1.1.1 Slope of concrete and asphalt areas near buildings.

Provide 1/4" slope at patio slabs, walks, and driveways away from building.

Effective on:	Dampwood Termites, Subterranean Termites and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	5% slope for the ground adjacent to the foundation for a minimum distance of 10 feet is required. (International Building Code Section 1804.3 (2012))
References:	Environmental Protection Agency, 2010

1.1.2 Backfill around foundations.

Tamp backfill to prevent settling and slope the final grade away from the foundation at a rate of 1/2 inch per foot over a minimum distance of 10 ft.

Effective on:	Dampwood Termites, Subterranean Termites and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Commonly required by local building codes
References:	US Environmental Protection Agency 2010, and Potter 1997

Principle 1.2 Reduce moisture in crawl spaces and under concrete slabs.

1.2.1 Vents maintenance.

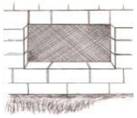
Air should flow freely (not blocked by shrubbery, mulch, or other landscape materials) through vents to reduce moisture levels. Maintain vent openings to crawl spaces.

Effective on:	Cockroaches, Dampwood Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Simmons, 2005

1.2.2 Subgrade membranes under concrete slab foundations.

Use a continuous, durable subgrade membrane sealed at all splices, perimeters, and protrusions in order to minimize foundation moisture problems. The membrane product selected should be specifically manufactured for use as a subgrade membrane and conform to ASTM E1745, latest edition, 0.1 perm maximum. Installation should conform to ASTM E1643, latest edition.

Effective on:	Ants, Dampwood Termites, Subterranean Termites, Misc. Wood Destroying Insects, Spiders, Misc. Insects
Compatibility Issues with Other Design Goals:	Building codes require this membrane to be a minimum Class 1 vapor retarder per ASTM E96 (International Residential Code R506.2.3 and International Building Code 1907.1 (2012)
References:	Technical Advisory Committee



Principle 1.3 Prevent pest access to crawl spaces.

1.3.1 Corrosion resistant, pest-resistant mesh on crawl space vents.

For any ground-level space (e.g. raised foundation crawl space) requiring foundation vents, specify corrosion resistant vent material (e.g. bronze) and a vent opening size smaller than the pest to be inhibited. For example, for typical ants and termites, use #50 bronze mesh between layers of ½ to 1-inch mesh for durability. Building codes generally require mesh with maximum opening of 1/4 inch, which will block rodent access.

Effective on:	Dampwood Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects. Misc. Insects, Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	As necessary, vent area should be increased to compensate for reduced air flow caused by smaller mesh sizes
References:	Technical Advisory Committee, and International Residential Code R408.2, International Building Code 1203.3.2

1.3.2 Clearance between crawl space ventilation and finished ground level.

Foundation vents should be at least 150 mm (6 inches) above finished ground level.

Effective on:	Dampwood Termites, Subterranean Termites and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Verkerk, 1990, p. 78-99

Principle 1.4 Access for inspections in the design of accessory structures that abut the foundation sidewall or other structures.

1.4.1 Clearance at accessory structures.

Provide 18" clearance beneath and 6" clearance between accessory structures and exterior wall coverings at decks, fences, patios, planters, and other accessory wood structures. If this clearance is not possible, construct accessory structures so that they are easily removable to allow inspection for termites.

Effective on:	Dampwood Termites, Drywood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Building codes require minimum clearances of 12 inches for wood beams and 18 inches for joists and floors to the exposed ground. (International Residential Code R317.1 and International Building Code 2304.11.2.1 (2012)
References:	Simmons, 2005

1.4.2 Access to foundations.

Provide easily removable components to allow access to foundation for inspections.

Effective on:	Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005

1.4.3 Concrete substructures.

In order to minimize entry of pests via joints, pour concrete patios as part of the main slabs.

Effective on:	Dampwood Termites, ,Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost issues and logistical issues
References:	Verkerk, 1990, p. 78-99

Principle 1.5 Eliminate wood and cellulose-containing material under and near structures.

1.5.1 Wood material adjacent to building.

No cellulose-containing material (wood scraps, form boards, vegetation, stumps, large dead roots, cardboard, trash, and foreign material) should be buried on the construction site within fifty feet of any building, especially in areas with high termite pressure.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005, and Technical Advisory Committee

Source: Inspectapedia.com

1.5.2 Fill material.

Fill material used around structures should be clean and free of vegetation and cellulose material.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005, and International Building Code 1804.2

1.5.3 Remove wood materials from masonry.

Prior to concrete placement, clean all cellulose-containing material from cells and cavities in masonry units to inhibit termite colonization.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Building codes refer to industry standards TMS602/ACI 530.1/ASCE6 for masonry foundation walls. (International Building Code 2104.1.2 and International Residential Code R404.1.1)
References:	Simmons, 2005

1.5.4 Remove extraneous wood materials after foundation construction.

After all foundation work is completed, remove all loose wood and debris from the crawl space and within one foot of the perimeter of the building.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005

Principle 1.6 Consider termite susceptibility in choice of foundation materials.

1.6.1 Steel posts in post and beam foundations.

Use steel posts for post and beam foundations, especially in areas with high termite pressure. The ends of the posts should be sealed at both ends with welded plates and the posts should be set in concrete foundations.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost issues
References:	Verkerk, 1990, p. 78-99

Source: Inspectapedia.com

1.6.2 Synthetic stucco.

In areas of high termite hazard, avoid Exterior Insulation and Finish Systems (EIFS, commonly referred to as synthetic stucco).

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Suiter and Forschler, 2009, and Potter, 1997, p. 281-282

Source: Inspectapedia.com

1.6.3 Foam insulation and foundation systems.

In areas of high termite hazard, avoid subgrade foam insulation on the exterior of the foundation, or pre-formed closed cell foam foundation systems.

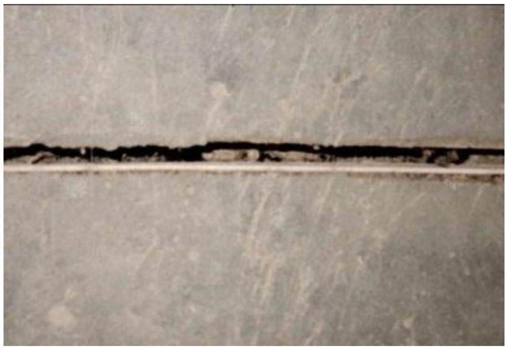
Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Subgrade foam treatments are sometimes recommended for energy conservation. Possible cost issues with eliminating use of foam foundation systems
References:	Suiter and Forschler, 2009, and Potter, 1997, p. 281-282

Principle 1.7 Minimize cracks more than 1 mm wide in concrete foundations and slabs.

1.7.1 Expansion joints.

Minimize need for expansion joints when designing slabs. When expansion joints are used, inspection access should be readily available and the use of termite-resistant mesh should be considered. In one study, 83% of subterranean termites entering buildings came in through expansion joints in concrete slabs.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	May conflict with the need to engineer for soil shifting. Best for new construction.
References:	Forschler, 2011, Verkerk, 1990, p. 78-99, and International Building Code 1901.2 (2012) 1804.2



Source: Inspectapedia.com

1.7.2 Voids in concrete.

In order to minimize voids in concrete slabs, mechanically compact concrete with a vibrator when pouring a slab.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Common practice for commercial construction, but may be difficult for residential renovations
References:	Verkerk, 1990, p. 78-99

1.7.3 Curing of concrete slabs.

Cure concrete slabs slowly to reduce shrinkage and cracks. Moist curing periods should generally not be less than seven days. Consult a structural engineer for design standards.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost issues
References:	Verkerk, 1990, p. 78-99

1.7.4 Anchors in concrete slabs.

Embed anchor bolts in slabs as the slab is poured. If additional anchors are necessary, use adhesive anchoring systems rather than expanding fasteners to avoid causing cracks.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	For building code requirements for anchor bolts, see International Building Code 1908, 1909 and International Residential Code R403.1.6.
References:	Verkerk, 1990, p. 78-99

1.7.5 Topical curing compounds for small foundations.

For foundations and slabs up to about 50 feet in dimension, use liberal applications of topical curing compounds to decrease cracking.

Effective on:	Ants, Dampwood Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee

1.7.6 Topical curing compounds or shrinkage admixtures for intermediate sized foundations.

For foundations about 50 to 100 feet in dimension, use adequate concrete reinforcing and proper concrete mix design, placement, finishing, and curing techniques. Additionally, use a shrinkage limiting concrete admixture.

Effective on:	Ants, Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost issues
References:	Technical Advisory Committee

1.7.7 Topical curing compounds or shrinkage admixtures for large foundations.

For foundations greater than about 100 feet in dimension, use adequate concrete reinforcing and proper concrete mix design, placement, finishing and curing techniques. Additionally, use a properly designed, shrinkage compensating concrete admixture.

Effective on:	Ants, Dampwood Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee

1.7.8 Integrated slabs are preferred. If joints are necessary, consider termite barriers.

Concrete slab foundations should be monolithic (floor slab integrated and poured simultaneously with footings). Unplanned construction joints should be minimized. In areas of high termite pressure any joints should be protected with mesh barriers or sand (graded stone) barriers. Mesh barriers should be laid on top of the vapor barrier and have a 15 mm accordion fold under the joint. Edges should be turned up 25 mm to be cast into the slab. The accordion fold should be protected by a strip of vapor barrier material so that the concrete does not bond to the accordion fold. Alternatively, a mesh barrier with an accordion fold can be parged to the top of the slab. Sand barriers should be confined within a void adjoining the joint that is at least 75 mm deep and at least 50 mm wide. A retainer cast into the slab should be used to confine the sand particles.

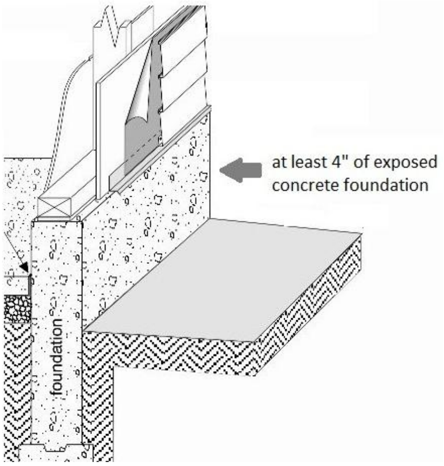
Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood-Destroying Insects
Compatibility Issues with Other Design Goals:	May be difficult to find contractors equipped for this kind of service
References:	Standards Australia International Ltd., 2000, and International Building Code F101.6.1.2 (2012)

Principle 1.8 Reduce opportunities for undetected termite access.

1.8.1 Visual access of upper edges of concrete slabs.

The upper 100 mm (4 inches) of the edges of a slab should remain exposed at all times; it should not be concealed by masonry, timber, soil, paving, etc.

Effective on:	Subterranean Termites
Compatibility Issues with Other Design Goals:	For building code requirements, see International Residential Code R404.1.6 (2012)
References:	Verkerk, 1990, p. 78-99

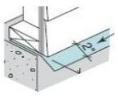


Source: Inspectapedia.com

1.8.2 Avoid indentations in edges of concrete slabs.

The vapor barrier underneath a slab should end no higher than the level of the finished soil or paving level. Slab formwork should include 100 mm (4 inches) of smooth faced timber around the top of the slab edge. The purpose of these construction details is to avoid indentations which allow undetected termite access.

Effective on:	Subterranean Termites
Compatibility Issues with Other Design Goals:	None identified
References:	Verkerk, 1990, p. 78-99

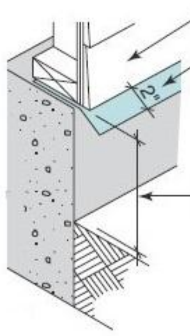


Principle 1.9 In areas of high termite hazard use shields or barriers with concrete slabs and foundations.

1.9.1 Appropriate materials and designs for termite shields.

If termite shields are used to reduce subterranean termite damage, they should be constructed of galvanized steel at least 0.5 mm thick; sheet copper at least 0.4 mm thick; stainless steel at least 0.4 mm thick; aluminum alloy at least 0.5 mm thick; copper and zinc alloys at least 0.5 mm thick; or woven stainless steel mesh. Joints and corners should be mitered and soldered, welded, or brazed. Shields should extend 70-80 mm past the foundation or foundation component. The last 30 mm of the shield should be bent downward at a 45 degree angle to reduce injuries during inspection. In addition, corners should be rounded The slippery metal of termite shields provides a poor footing for termites and their tubes, although there is controversy about their effectiveness. They are perhaps most valuable for increasing the ability of inspectors to spot signs of infestation. The shields should be constructed by qualified professionals, with no gaps for termite access, and in settings that permit inspection.

Effective on:	Subterranean Termites
Compatibility Issues with Other Design Goals:	Cost issues
References:	Standards Australia International Ltd., 2000, and Steve Dwinell, Fresh from Florida



Source: Inspectapedia.com

1.9.2 Mesh barriers for termite exclusion.

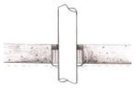
When stainless steel mesh is used as a termite barrier, the mesh should be made from grade 304 or 316 wire with a minimum diameter of 0.18 mm. The maximum aperture size should be 0.66 mm x 0.45 mm. This maximum size should be reduced if local termite species are known to be small. As necessary the mesh should be parged to concrete foundations with a grout consisting of water-dispersed copolymer, Type GP Portland cement and sieved aggregate that can pass through the stainless steel mesh. The mesh should not contact dissimilar metals that will produce a corrosion reaction. If pieces of mesh need to be joined, the joint should consist of an area 10-15 mm wide where the edges of the two pieces are folded together 2 1/2 times or a parged area 35 mm wide where the pieces overlap. Mesh can be used as a perimeter barrier for masonry exterior walls when parged to the concrete slab, draped across the cavity, and then built into the exterior wall. It can also be used as a continuous barrier under concrete slabs, or as a barrier under joints and for utility penetrations.

Effective on:	Dampwood Termites and Subterranean Termites
Compatibility Issues with Other Design Goals:	May add to cost of construction. Not available in many areas. Building codes recognize the barrier concept (International Residential Code R318.3 (2012)
References:	Standards Australia International Ltd., 2000

1.9.3 Sand or basalt barriers for termite exclusion.

Where graded particles (sand or basalt) are used as a termite barrier, the particles should be graded and shaped so that a sufficient proportion of them are of a size that cannot be transported by local termite species. They also should be able to be placed so that voids between particles to not permit penetration of local termite species. They can be either igneous or metamorphic stone. The wet/dry analysis must have less than 35% variation and their specific gravity must be at least 2.52. Graded particles can be used as a perimeter barrier when installed in wall cavities or in a trench around the foundation. In either case the minimum depth of the particles should be 75 mm. Trenches should be at least 100 mm wide. Graded particles can also be used as a continuous under-slab barrier. These barriers should be 75-100 mmm deep and compacted with a vibrating plate-type tamper. Graded particles can also be used as a barrier under joints and around utility penetrations. Appropriate diameters for particles are 1.2-1.7 mm for the western subterranean termite, 1.7-2.8 mm for the eastern subterranean termite, and 1.7-2.4 mm for the Formosan termite.

Effective on:	Dampwood Termites and Subterranean Termites
Compatibility Issues with Other Design Goals:	Graded sand or basalt is not widely available
References:	Yates III et al., 2000, and Standards Australia International Ltd., 2000



Principle 1.10 All points where utilities go through the slab should be readily accessible for inspection. Gaps between penetrations and slab should be sealed using epoxy as a sealant, mesh barriers, or sand barriers.

1.10.1 Epoxy sealants for utility breaks.

Use epoxy immediately prior to pouring a slab to seal concrete around utilities.

Effective on:	Ants, Dampwood Termites, and Subterranean Termites
Compatibility Issues with Other Design Goals:	None identified
References:	Standards Australia International Ltd., 2000, and Verkerk, 1990, p. 78-99

1.10.2 Mesh barriers for utility breaks.

Mesh barriers should consist of a flange of mesh 50 mm wide. The mesh flange should be attached to the penetrating utility with a stainless steel clamp and embedded in the slab. Alternatively, the mesh flange can be attached with a stainless steel clamp and then parged to the top surface of the slab.

Effective on:	Ants, Dampwood Termites, Subterranean Termites
Compatibility Issues with Other Design Goals:	Installers of termite mesh are not widely available.
References:	Standards Australia International Ltd., 2000, and Verkerk, 1990, p. 78-99

1.10.3 Sand barriers for utility breaks.

For sand barriers, concrete should be poured in a circular area 25 mm around the utility pipe. That void should then be filled with sand at least 75 mm deep. See 1.9.3 for sand specifications. The sand should be capped at the top of the slab, and a retainer cast into the slab below the sand should be used to prevent sand loss beneath the slab.

Effective on:	Subterranean Termites, Dampwood Termites
Compatibility Issues with Other Design Goals:	Appropriate products are not widely available.
References:	Standards Australia International Ltd., 2000, and Verkerk, 1990, p. 78-99

Principle 1.11 Maintain adequate clearance between wood foundation components and soil.

1.11.1 Minimum clearance.

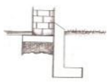
There should be a minimum clearance of 18 inches between beams or joists and soil.

Effective on:	Dampwood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Building codes require minimum clearances of 12 inches for wood beams and 18 inches for joists and floors (International Residential Code R317.1 and International Building Code 2304.11.2.1 (2012)
References:	Verkerk, 1990, p. 78-99

1.11.2 Increased minimum clearance.

In areas of high termite hazard, clearance between beams or joists and soil should be 36 inches.

Effective on:	Dampwood Termites, Subterranean Termites
Compatibility Issues with Other Design Goals:	None identified
References:	Verkerk, 1990, p. 78-99

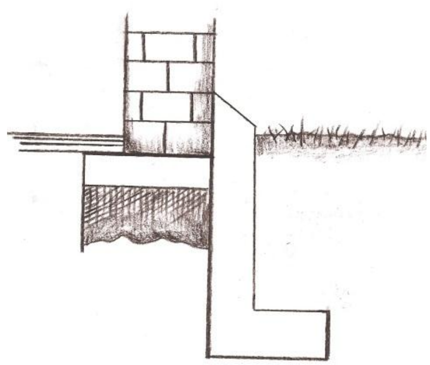


Principle 1.12 Use "curtain walls" around and below a foundation where necessary.

1.12.1 Effective designs for curtain walls.

Rats often burrow under foundations of buildings without basements. Vertical curtain walls 2 feet (0.6 m) below the surface with an 8 inch (20 cm) horizontal "L" or flange directed away from the building are usually effective in preventing rats from burrowing under foundations. Construct curtain walls of 29-gauge corrugated iron, concrete, or bricks.

Effective on:	Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	For code requirements, see International Building Code Appendix F, Section F101.6.1.1 (2012)
References:	Corrigan, 1997, p. 59, Hoddenbach et al., 1997, and International Building Code Appendix F, Section F101.6.1 (2012)



Source: Corinne Smith, Center for Environmental Health

Principle 2.1 Use siding made from durable materials.

2.1.1 Wood siding.

For wood siding, durable species include Western red cedar, Redwood, and (less commonly) Incense cedar, Port Orford cedar, Black locust, Northern white cedar, Eastern red cedar, and Alaska yellow cedar. Only heartwood of these species has resistant qualities.

Effective on:	Dampwood Termites, Drywood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost issues. Not protective against all wood-destroying pests (for example, carpenter ants and carpenter bees)
References:	Scheffer and Morrell, 1998, Lewis, 2001, and International Building Code 202 definition of naturally durable wood (2012)

Source: Inspectapedia.com

2.1.2 Non-wood siding options.

Other pest-resistant siding options include fiber-cement, aluminum, and steel. Some of these materials may not be appropriate for residential structures.

Effective on:	Dampwood Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues, Cost issues, and Environmental considerations. Breakage and cracking may occur with some non-wood siding options.
References:	Karsky and Neese, 2000

Principle 2.2 Install and finish siding to minimize gaps, warping, and cracking.

2.2.1 Caulk and sealant for siding installation.

On siding, use high quality, exterior grade caulks and sealants that meet ASTM standard C-920. Caulk should be compatible with both siding materials and trim materials.

Effective on:	Ants, Cockroaches, Spiders, Wasps, Bees, Misc. Insects, and Mice
Compatibility Issues with Other Design Goals:	Building codes mandate the use of ASTM C-920 caulk in other locations. Caulking requires careful installation and maintenance. Avoid high-VOC caulks.
References:	CertainTeed Corporation, 2010, and Pontolilo, 2004

Source: Inspectapedia.com

2.2.2 Areas to be caulked or sealed during siding installation.

Caulk or seal the following areas: wherever siding meets trim, around windows and doors, and around any penetrations (pipes, wires, etc.) that are not self-flashing.

Effective on:	Ants, Cockroaches, Wasps, Bees, Spiders, Misc. Insects, and Mice
Compatibility Issues with Other Design Goals:	For code requirements see International Residential Code Table N1102.4.1.1 and International Energy Conservation Code R402.4.1 and C402.4.2
References:	CertainTeed Corporation, 2010

Source: Inspectapedia.com

2.2.3 Back flashing at siding butt joints.

Use back flashing at siding butt joints to minimize openings that might allow entry of pests.

Effective on:	Ants, Cockroaches, Wasps, Bees, Spiders, Mice, and Rats
Compatibility Issues with Other Design Goals:	Compatible with code requirements for water resistance (International Building Code 1403.2 and International Residential Code R703.1.1 (2012)
References:	CertainTeed, 2010

Source: Inspectapedia.com

Principle 2.3 Provide sufficient clearance between siding and soil.

2.3.1 Siding or stucco installation.

Siding and stucco should begin at least six inches above soil level. This decreases the risk of subterranean termites reaching the wood, and makes their mud tubes more visible to inspectors.

Effective on:	Subterranean Termites, Dampwood Termites, Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues. For code requirements see International Building Code 2304.11.3.6 and International Residential Code R317.1 (2012).
References:	Simmons, 2005, and Florida Building Code Section 1403.7 (2010)

Source: Greg Axten

Principle 3.1 Choose exterior light fixtures to discourage bird roosting and nesting.

3.1.1 Bird-resistant light fixtures.

Choose light fixtures with sloping surfaces rather than horizontal surfaces to deter bird roosting and nesting.

Effective on:	Pigeons and Misc. Birds
Compatibility Issues with Other Design Goals:	Aesthetic and Functional issues
References:	Kern, Jr., 1996

3.1.2 Bird deterrents on light fixtures.

Install bird spikes, "porcupine wire," netting, or similar devices to discourage birds from nesting on light fixtures.

Effective on:	Pigeons and Misc. Birds
Compatibility Issues with Other Design Goals:	Aesthetic issues and cost issues. Bird spikes and netting may be unsightly in some locations. Installation is expensive and barriers must be maintained. Not always 100% effective.
References:	University of Florida, 2008, and Bennett, 2010, p. 462-463

3.1.3 Bird exclusion devices.

Use bird exclusion devices, including wires, springs, nets, and electrical strips, to prevent birds from reaching light fixtures.

Effective on:	Pigeons and Misc. Birds
Compatibility Issues with Other Design Goals:	Aesthetic issues and cost issues. Requires maintenance, and not always 100% effective.
References:	Bennett, 2010, p. 462-463, and Timm et al., 2011

Principle 3.2 Design and install exterior light fixtures to minimize attraction of flying insects.

3.2.1 Motion detectors on exterior lights.

Motion detectors allow lights to be on for shorter amounts of time and can reduce accumulation of insects around lights.

Effective on:	Flies and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues, energy issues, and security issues. Frequently travelled pathways may not be appropriate for motion detector lights. Motion detectors are suggested as energy conservation measures.
References:	Technical Advisory Committee

3.2.2 Timers on exterior lights.

Use timers to restrict light operation to high traffic times as appropriate. This may reduce the volume of insects attracted to the lights.

Effective on:	Flies, Mosquitoes, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues and security issues. If security is a major concern, lights may need to remain on even during low-traffic periods.
References:	Technical Advisory Committee, and International Energy Conservation Code C405.2.4

3.2.3 Reflected light rather than direct light.

Use reflected light rather than direct light to illuminate doorways, as appropriate and allowed by local codes. Insects are more attracted to point sources of light and are therefore less likely to enter doorways.

Effective on:	Flies, Mosquitoes, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic, functional, security, and legal issues. Need to meet code requirements for egress lighting.
References:	Green and Gouge, 2009, and International Building Code Section 1006

3.2.4 Direct exterior lighting only for essential areas.

Minimize direct lighting to high priority areas that maximize resident safety, especially near structures. All such lighting should meet local code requirements. This will minimize insect attraction to point source lights.

Effective on:	Flies, Mosquitoes, and Misc. Insects
Compatibility Issues with Other Design Goals:	Need to ensure that safety and security requirements are met
References:	Technical Advisory Committee, and International Building Code Section 1006 (2012)

3.2.5 Yellow (sodium) exterior lights.

Use yellow lights ("bug" bulbs or sodium vapor lights, for example) in exterior areas where insect attraction to lights is an issue. Both intensity and color are important in insect attraction.

Effective on:	Flies, Mosquitoes, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues and functional issues. Local code requirements vary. Some users likely to find yellow light "ugly." Yellow light distorts color perception and may be perceived as being less bright than full-spectrum light of the same intensity.
References:	Ali et al., 1984, Marer, 1991, p. 17, and International Building Code Section 1006 (2012)

Principle 4.1 Direct rainwater away from walls.

4.1.1 Discharge from downspouts and gutters.

To minimize moisture accumulation, all downspouts and gutters should discharge at least one foot away from structure wall, using a connection to storm sewers, tail extensions, splash blocks, or dry wells.

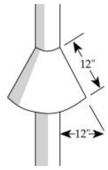
Effective on:	Dampwood Termites, Subterranean Termites, Misc. Wood Destroying, and Misc. Insects
Compatibility Issues with Other Design Goals:	Required by some building codes
References:	Florida Building Code, 2010, and Richman et al., 1999

4.1.2 Placement of gutters with downspouts.

Use gutters with downspouts on all buildings with eaves of less than 6 inches of horizontal projection except for gable ends and roofs above other roofs.

Effective on:	Dampwood Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Florida Building Code, 2010

Source: Inspectapedia.com



Principle 4.2 Prevent rodents from using downspouts and pipes to climb up exterior walls.

4.2.1 Flap valves or mesh on downspouts.

In areas of high rodent pressure, use flap valves to prevent rodents from entering downspouts. Mesh is also an option, but periodic cleaning will be necessary.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	A single rain event during autumn when leaves are falling can clog mesh. Mesh or flaps must allow adequate water flow to avoid damage to structure.
References:	Hygnstrom et al., 1994, and Technical Advisory Committee

4.2.2 Cones and discs.

In areas of high rodent pressure, use cones or discs (typically metal) to prevent rodents from traveling up downspouts and pipes. Cones should be mounted with the wide end of the cone facing down and should be 12 inches in diameter and 12 inches long. Discs should be 18 inches in diameter.

Effective on:	Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Aesthetic issues; need to be designed and installed so that they don't present hazards to persons working on building exterior
References:	Hygnstrom et al., 1994, and Bennett, 2010, p. 425

4.2.3 Vertical pipes.

Prevent mice and Norway rats from climbing on exterior vertical pipes by applying a 12 inch band of glossy paint around the pipe.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Aesthetic issues; paint will need periodic maintenance.
References:	Bennett, 2010, p. 425

4.2.4 Strainer leaf guards.

Use expanded strainer leaf guards (made for keeping leaves out of downspouts) to keep rodents from entering open pipes.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Will require maintenance to remove leaves when necessary
References:	Simmons, 2005

Principle 4.3 Design building perimeter to be unattractive to pests.

4.3.1 Gravel strip around perimeter of foundation.

To discourage rodent burrowing, install a gravel strip of 1-inch (2.5 cm) diameter or larger, laid in a band at least 2 feet (60 cm) wide and 1/2 foot (15 cm) deep.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Aesthetic issues. Most appropriate for commercial buildings.
References:	Hygnstrom et al., 1994

4.3.2 Plant-free strips around structures.

Maintain plants, grass, and mulch several inches away from the foundation of buildings to minimizing nesting sites for ants.

Effective on:	Ants, Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Klotz and Rust, 2007

4.3.3 Exterior landscaping.

Design exterior landscaping so it does not cause moisture build-up around the foundation. Consider use of drip irrigation. Maintain clearances between vegetation and exterior walls.

Effective on:	Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic and cost issues. Drip irrigation is commonly required or recommended for water conservation.
References:	Simmons, 2005, and Technical Advisory Committee

Principle 4.4 Design accessory structures, fences, posts, planter boxes, and stairs to minimize termite problems.

4.4.1 Contact between accessory structures and the main building.

Construct decks, fences, patios, planters, or other wooden structural components that directly abut the sidewall of the foundation or structure to provide: (a) an 18-inch clearance beneath the component, or (b) a 6-inch clearance between the top of the component and the exterior wall covering, or (c) have components that are easily removable by screws or hinges to allow access for inspection of the foundation sidewall.

Effective on:	Dampwood Termites and Subterranean Termites
Compatibility Issues with Other Design Goals:	Aesthetic issues and possible functional issues depending on the nature of the accessory structures; for code requirements (12 inches for beams and 18 inches for joists and floors) see International Residential Code R317.1 and International Building Code 2304.11.2.1 (2012).
References:	Simmons, 2005, and University of Florida, 2009

4.4.2 Termite-resistant fence and post materials.

Use termite-resistant fence and post materials, including naturally durable wood, concrete and steel.

Effective on:	Dampwood Termites, Drywood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost issues. However, durability increases cost effectiveness. For code requirements about use of pest-resistant materials see International Building Code 2304.11.6 and International Residential Code R318.1 (2012).
References:	

4.4.3 Wood steps above grade.

Wood steps should rest on a concrete base at least 6 inches above grade to minimize access by wood-destroying pests, particularly in areas with high termite pressure.

Effective on:	Subterranean Termites, Dampwood Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost issues and aesthetic issues if non-wood alternatives are used
References:	University of Florida, 2009

Principle 4.5 Prevent animal access under sheds, decks, and porches.

4.5.1 Use of metal mesh.

Install quality 1/4 or 1/2 inch galvanized hardware cloth from the bottom of the shed/porch/decks without perimeter foundations to 3-4 inches below the ground and then out in a perpendicular fashion at least 12 inches from the vertical line. To improve appearance of hardware cloth used under sheds, decks, and porches, cover with lattice after installation.

Effective on:	Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues. Wood lattice may encourage climbing pests. Make sure wood lattice is at least 6 inches from soil.
References:	Internet Center for Wildlife Damage Management, 2005

Principle 4.6 Design and construct exterior building surfaces to minimize pest access to interior.

4.6.1 Holes or joints in exterior or other cavity walls.

Seal all holes or joints in exterior or other cavity walls that are larger than 1/4 inch diameter to prevent access by mice. Where larger holes or joints are necessary they should be screened with 1/4" mesh or otherwise shielded from pest intrusion. Seal smaller holes to eliminate access from smaller pests. Use caulk (non-elastomeric, does not return to original shape when stretched or compressed) for openings of 1/4" diameter or less. Use an elastomeric sealant to close larger openings. Use a liquid sealer to close pores and hairline cracks.

Effective on:	Mice and Rats
Compatibility Issues with Other Design Goals:	For code requirements see International Residential Code Table N1102.4.1.1 and International Energy Conservation Code R402.4.1.1 and C402.4.2. Cost issues for existing buildings
References:	Technical Advisory Committee, and Hopkins, 2002

4.6.2 Concrete masonry unit walls.

“Cap” concrete masonry unit walls by filling the top row of blocks with cement to eliminate rodent access to the interior of the wall.

Effective on:	Mice and Rats
Compatibility Issues with Other Design Goals:	Cost issues.
References:	Corrigan, 2008

4.6.3 Sealing along foundation for standard stucco weep-screed construction.

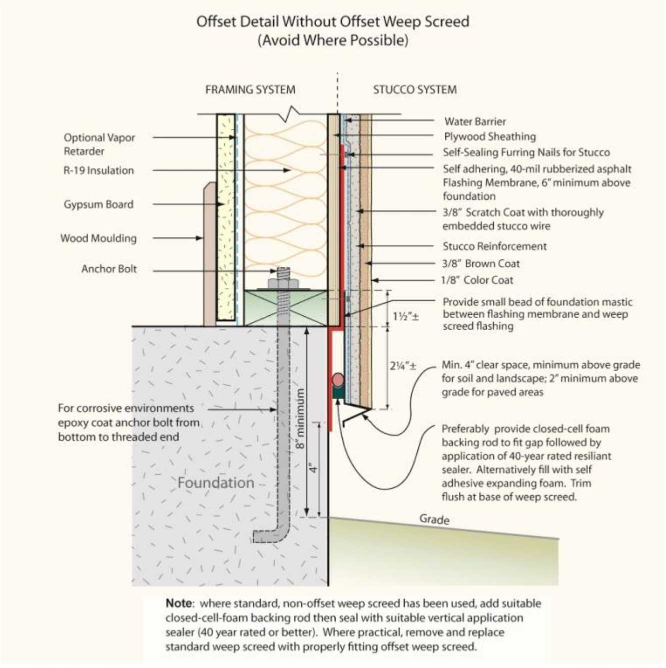
For standard stucco weep-screed construction, seal along foundation with 6-inch minimum rubberized asphaltic, self-adhesive membrane extending down over foundation 1-2 inches. At point above screed section, also seal back of flashing to foundation with generous bead of foundation mastic. Use vinyl weep screed in corrosive environments.

Effective on:	Dampwood Termites, Subterranean Termites, Wasps, Bees, Spiders, Misc. Insects
Compatibility Issues with Other Design Goals:	For minimal code requirements see International Building Code 2512.1.2 and International Residential Code R703.6.2.1 (2012).
References:	Technical Advisory Committee

4.6.4 Appropriate flashing for stucco walls with offset weep-screed.

For offset weep-screed installation use weep-screed flashing with offset in the flashing equal to actual framing offset. Install per standard weep-screed construction procedures except use 8-inch minimum self-adhesive membrane extending to bottom of weep-screed. Use small bead of caulking between base of framing and flashing.

Effective on:	Ants, Spiders, Subterranean Termites, Dampwood Termites, Misc. Wood Destroying, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee

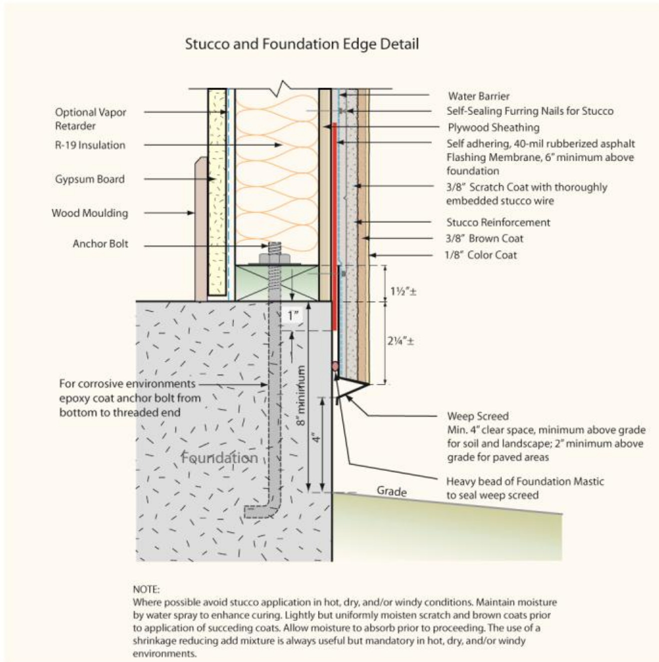


Source: Greg Axten

4.6.5 Sealing for stucco walls with offset framing and standard weep screed.

For offset framing where standard weep screed was used, install closed-cell-foam backing rod between foundation and flashing. Apply suitable, vertical application and resilient caulking between foundation and flashing. Alternatively fill gap between foundation and flashing with self-adhering, expanding foam. Upon cure, trim flush with base of flashing.

Effective on:	Ants, Spiders, Subterranean Termites, Dampwood Termites, Misc. Wood Destroying, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee



Source: Greg Axten

Principle 4.7 Design building exterior to minimize attractiveness for roosting birds.

4.7.1 Design exterior structures to minimize bird perching, roosting, or nesting.

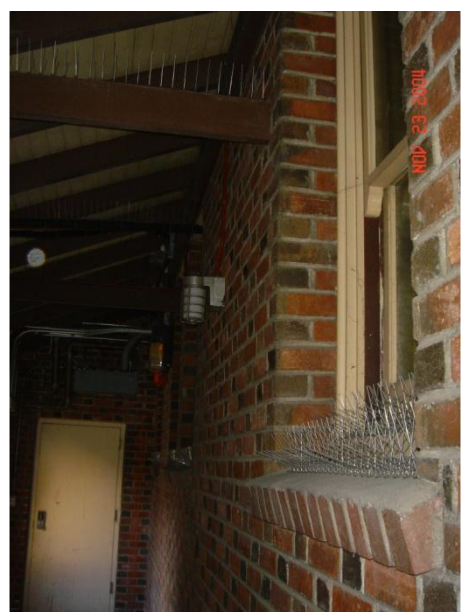
Design exterior structures like decorative screens, moldings and lattices, siding, awnings, window sills, signs, fire sprinkler pipes, and column capitals so that they do not provide opportunities for bird perching, roosting, or nesting especially near building entrances. Use smooth materials and avoid horizontal surfaces. Where necessary, retrofit existing structures with exclusion devices (looped wires, sheet metal spikes, springs, nets, etc.), although these devices are not foolproof and require maintenance. Openings in buildings, exposed rafters on overhanging dock roofs, or any likely perches in semi-enclosed areas can be screened with rust-proof, 3/4 inch wire or plastic mesh, or 1/2 inch mesh to also exclude rodents. Plastic netting is less durable and must be replaced more often.

Effective on:	Pigeons and Misc. Birds
Compatibility Issues with Other Design Goals:	Aesthetic issues; installers of bird exclusion devices not available in all areas
References:	Technical Advisory Committee, and Bennett et al., 2010, p. 462-463

4.7.2 Avoid semi-enclosed spaces or alcoves.

Semi-enclosed alcoves or courtyards, especially with open roofs, provide ideal roosting and nesting opportunities for pigeons and other birds. If these structures must be included in the building design, include bird barriers and minimize horizontal surfaces.

fective on:	Pigeons and Misc. Birds
Compatibility Issues with Other Design Goals:	Aesthetic issues and functional issues
References:	Technical Advisory Committee



Source: San Francisco Dept. of the Environment

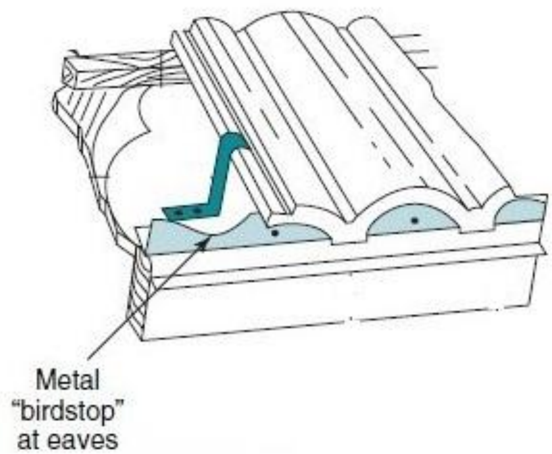
Roofs

Principle 5.1 Construct roofs to reduce pest access into the building structure.

5.1.1 Bird stops on tile roofs.

Fit eave roof tiles with commercially available bird stops, which also exclude bats and flying insects.

Effective on:	Misc. Birds, Pigeons, Bees, Wasps, Misc. Insects, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Hygnstrom et al., 1994



Source: Inspectapedia.com

5.1.2 Screens for attic vents and chimneys.

Attic and chimney screens can prevent problems with bats, squirrels, and birds. In areas of where drywood termites are known to be a problem, consider replacing screens on attic vents (typically 1/4 inch) with window screening. This may not be appropriate in damp climates, because the smaller mesh screening can impede air flow. Building codes generally allow attic vent screening as long as the mesh size is greater than 1/16 inch.

Effective on:	Bats, Rats, Raccoons, Opossums, Drywood termites, Dampwood termites, Misc. Birds, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Smaller mesh screen reduces air flow. Ensure that ventilation requirements are met.
References:	Gouge et al., 2001, Guillebeau and Ipser, 2001, and International Building Code 1203.2.1 and International Residential Code R806.1

Principle 6.1 Design and maintain landscape areas near buildings to minimize the number and types of pests.

6.1.1 Tree branch maintenance.

Maintain at least 6 feet of clearance between exterior walls and tree limbs/branches that might provide vertebrate pest access (10 feet if tree squirrels are a problem).

Effective on:	Mice, Rats, Opossums, Raccoons, and Misc. Mammals
Compatibility Issues with Other Design Goals:	Aesthetic issues. Possible conflicts with local tree preservation requirements. May assist in compliance with local requirements for defensible zones for fire protection. (See International Wildland Urban Interface Code 604.4 (2012)
References:	Bennett, 2010, p. 487

6.1.2 Fruit trees that are attractive to pests.

Use plants that shed a minimum of seeds and fruits, since the seeds and fruit may attract and support insects, rodents, and undesired birds.

Effective on:	Ants, Wasps, Bees, Misc. Insects, Mice, Rats, Opossums, Raccoons, Misc. Mammals, Misc. Birds
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Simmons, 2010

6.1.3 Landscape plants that are attractive to rats.

Avoid planting Algerian or English ivy, star jasmine, and honeysuckle on fences or buildings, as they provide shelter and food for rats.

Effective on:	Rats, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Timm et al., 2011

6.1.4 Landscape plants that are attractive to ants.

Where Argentine ants are common, avoid bamboo, cherry laurel, fig, pine, and roses near buildings. These plants often have abundant scale and aphid populations, and excreta from these insects provides food for ant colonies.

Effective on:	Ants
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Marer, 1991, p. 86, and Technical Advisory Committee

6.1.5 Plants with dense canopies.

Separate the canopy of densely growing plants from one another and from buildings by a distance of 2 feet or more to make it more difficult for rats to move between them.

Effective on:	Mice, Rats
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Timm et al., 2011

6.1.6 Wood mulch.

Decorative wood chips and mulch should be used sparingly in situations where termite infestation is a high probability. Wood chips should never be allowed to contact wood siding or framing of doors or windows. Crushed stone or pea gravel are alternative solutions and may also discourage ants and spiders.

Effective on:	Ants, Subterranean Termites, Spiders
Compatibility Issues with Other Design Goals:	Aesthetic and water conservation issues. Since wood mulch helps conserve water and reduce weed infestations, using alternate materials may impact landscape management approaches.
References:	Potter, 1997, p. 280, and Technical Advisory Committee

Principle 7.1 Construct interior walls to minimize harborage and pathways for insect and rodent pests.

7.1.1 Baseboard installation.

Use straight base rather than cove base. Cove bases are typically installed with adhesives that may be food for cockroaches, and the gap behind the cove provides potential harborage for a variety of pests, including bed bugs. Alternately, use cove bases that have no gap, and install them to be more easily removable (using screws or nails) to make inspection and treatment easier.

Effective on:	Bed Bugs, Cockroaches, Ants, Misc. Insects
Compatibility Issues with Other Design Goals:	Cove baseboards make cleaning corners easier; using straight bases may affect custodial operations.
References:	Allen, 2009

Source: San Francisco Dept. of the Environment

7.1.2 Gaps between wall and flooring.

In an interior wall made of wood and drywall, the bottom plate is not usually completely tight against the floor due to uneven floors and the natural bends in wood. Similarly, the drywall panels that are hung on the wall framing often have a gap along the bottom edge. Gaps should be minimized as much as possible during construction.

Effective on:	Ants, Bed Bugs, Cockroaches, Mice, and Rats
Compatibility Issues with Other Design Goals:	May be difficult to achieve because of building movement caused by soil expansion and contraction. Architects/designers/contractors will need to check during construction to verify implementation of this guideline.
References:	Allen, 2009

Principle 8.1 Floors should be durable, non-absorbent, without crevices, and capable of being effectively cleaned.

8.1.1 Concrete.

Concrete floors should be durable, steel-float finished and sealed to prevent dirt accumulation in crevices and provide a non-slip surface.

Effective on:	Ants, Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues and Cost issues
References:	Simmons, 2005, and United Nations World Food Programme, 2009

8.1.2 Carpet.

Avoid installing carpet in areas prone to moisture: bathrooms, laundry rooms, kitchens, entryways and damp basements. Moisture promotes fungal growth and accompanying insect infestations.

Effective on:	Cockroaches, Fleas, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues, acoustical issues
References:	Lstiburek and Brennan, 2001

Source: Inspectapedia.com

Principle 9.1 Floors should be durable, non-absorbent, without crevices, and capable of being effectively cleaned.

9.1.1 Moisture resistant materials in commercial kitchens.

In commercial food preparation areas, use quarry tile, poured seamless epoxy floor, approved commercial grade vinyl, or similar materials to avoid moisture accumulation and harborage of insect pests.

Effective on:	Ants, Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost issues. Vinyl materials not recommended for environmental reasons.
References:	California Conference of Directors of Environmental Health, 2008

Source: San Francisco Dept. of the Environment

Principle 9.2 Design floor drains for complete drainage and easy cleaning.

9.2.1 Floor slope.

Where floor drains are installed, slope surrounding floors 1/4 inch per foot to the drain.

Effective on:	Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	California Conference of Directors of Environmental Health, 2008

9.2.2 Drain covers and baskets.

Cover floor drains with mesh screen covers or sunken drain baskets. Baskets or covers should be removable for cleaning. Codes usually require removable strainers.

Effective on:	Cockroaches, Flies, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	Functional issues relating to access to the drains
References:	Green and Gouge, 2009, and International Residential Code P2719.1 and International Plumbing Code 412.2 (2012

Source: San Francisco Dept. of the Environment

9.2.3 Floor drain access.

Floor drains should be easily accessible to enable cleaning and inspection. Floor drains should not be located under fixed kitchen equipment.

Effective on:	Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	Functional issues relating to arrangement of drains in room. Most codes have similar requirements.
References:	United Nations World Food Programme, 2009, Hygnstrom et al., 1994, and International Residential Code P2719.1 and International Plumbing Code 412.2 (2012)

Principle 10.1 Reduce pest access through doors.

10.1.1 Solid-core doors.

Use solid-core doors where possible. Solid-core doors are more durable and do not have hidden recessed areas or cavities that could harbor pests.

Effective on:	Ants, Bed Bugs, Cockroaches and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost and aesthetic issues
References:	Simmons, 2005, and Smith and Whitman, 2007, p. 1.0.3

10.1.2 Doors with metal kick plates.

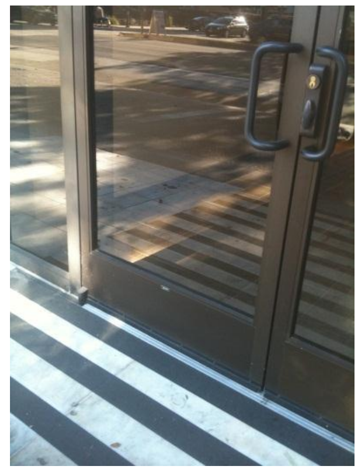
In areas of high rodent pressure, fit external doors with 26-gauge sheet metal kick plates 12 inches tall and mounted no more than 1/4 inch from the bottom of the door. Metal plates should not interfere with the swinging of the door.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Aesthetic and cost issues
References:	Bennett, 2010, p. 425, and International Building Code Appendix F, Section F101.4 (2012)

10.1.3 Thresholds of exterior doors.

Doors should fit tightly; the distance between the bottom of the door and the threshold should not exceed 1/4 inch. Use tight-fitting door sweeps if gaps are larger than 1/4 inch. If appropriate, use automatic door sweeps, which drop to seal against the floor when the door is closed. If automatic sweeps are not possible, bristle sweeps are preferable to rubber or plastic. If rodent pressure is high, protect rubber and plastic sweeps with metal kick plates installed on the outside of the door.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues with automatic door sweeps. For code requirements see International Building Code Appendix F, Section F101.4 (2102).
References:	University of Florida, 2008, Hoddenbach et al., 1997, and Technical Advisory Committee.



Source: Center for Environmental Health

10.1.4 Air curtains.

In commercial buildings, specify air curtains (air doors) where doors are frequently open. Use models that start automatically when the door is opened to conserve energy. Properly installed and sized air curtains are typically about 80% effective in preventing insect entrance. Users have reported over 99% reduction in fly numbers.

Effective on:	Flies, Mosquitoes, and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost, energy conservation and HVAC issues
References:	McKenna, 2002, and Berner International

10.1.5 Self-closing doors.

All doors leading to the outside should be equipped with self-closing devices and supplementary screen doors. For large overhead doors, such as warehouses or processing facilities, consider electrically operated screen doors or a permanent frame with screening. As appropriate, make sure the closure mechanisms are safe for children and the elderly. Follow manufacturer's safety instructions for closure mechanisms.

Effective on:	Flies, Spiders, Misc. Insects, Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues, aesthetic issues, handicap accessibility issues
References:	Simmons, 2005, and Ehmann, 1997, p. 788

10.1.6 Screen doors.

Use screen doors with durable frames to prevent warping and ensure a good seal from the outdoors.

Effective on:	Flies, Mosquitoes, Wasps, Bees, and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost issues
References:	University of Florida, 2008

10.1.7 Weather-stripping of exterior doors.

Use weather-stripping of all exterior doors to better seal against pest entry.

Effective on:	Ants, Cockroaches, Flies, Mosquitoes, Wasps, Bees, Misc. Insects, and Mice.
Compatibility Issues with Other Design Goals:	Often required as an energy conservation measure
References:	Marer, 1991, p. 19, and International Energy Conservation Code R402.4.3 and C402.4.3

Principle 11.1 Design and construct windows to minimize pest attraction and access to interior.

11.1.1 Window ledges.

Slope smooth-surfaced window ledges and projections at 45 degrees to minimize bird perching and roosting.

Effective on:	Pigeons, Misc. Birds
Compatibility Issues with Other Design Goals:	Aesthetic issues, Design issues, and Safety issues
References:	Simmons, 2005

Source: iStockphoto

11.1.2 Screens.

International Property Maintenance Code requires screens on windows in habitable rooms as well as rooms used for food storage and preparation unless air curtains or fans are employed.

Effective on:	Ants, Cockroaches, Flies, Mosquitoes, and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost issues. Reduces light and air flow.
References:	Bennett, 2010, p. 345, and International Property Maintenance Code 304.14 (2012)

11.1.3 Weather-stripping.

Use weather-stripping for all operable windows.

Effective on:	Ants, Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	Generally required as an energy conservation measure
References:	Marer, 1991, p. 19, and International Energy Conservation Code R402.4.3 and C402.4.3

Principle 12.1 Minimize bed bug harborage

12.1.1 Moldings and joints.

Moldings and joints around the room perimeter (floor, doors, cabinets, and windows) should be caulked with silicone sealant to eliminate hiding spots for bed bugs.

Effective on:	Bed Bugs, Cockroaches, Ants, and Misc. Insects.
Compatibility Issues with Other Design Goals:	Code requirements (International Residential Code Table N1102.4.1.1 and International Energy Conservation Code R402.4.1.1 and C402.4.2 apply if gaps involve the building thermal envelope
References:	Gangloff-Kaufmann and Pichler, 2008

12.1.2 Hard flooring materials.

Use wood, tile, linoleum, or similar flooring materials instead of carpets or rugs.

Effective on:	Bed Bugs and Misc. Insects.
Compatibility Issues with Other Design Goals:	Aesthetic issues. Acoustical issues.
References:	Bay Area Local Initiatives Support Corporation, 2006

12.1.3 Built-in furniture.

Built-in furniture provides harborage for bedbugs that is difficult to inspect. If built-in furniture is used, provide access for inspection.

Effective on:	Bed Bugs, Cockroaches, Ants, and Misc. Insects.
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Bay Area Local Initiatives Support Corporation, 2006

12.1.4 Furniture that minimizes attractiveness to bedbugs.

Use leather, metal, plastic or laminate furniture rather than upholstered, wicker, or wood furniture. Metal and laminate furniture is harder for bedbugs to climb than wood furniture. If upholstered furniture is used, it should have metal legs and the fabric should be at least a few inches from the floor and from any other pieces of furniture. If possible, use furniture that is easily washable and light colored. Beds should not have headboards and mattresses should be encased in commercially available, insect-proof coverings.

Effective on:	Bed Bugs and Misc. Insects.
Compatibility Issues with Other Design Goals:	Cost and aesthetic issues
References:	Bay Area LISC and Bed Bug Task Force, 2006, and Gangloff-Kaufmann and Pichler 2008

Principle 12.2 Seal openings that allow bedbug movement between rooms or units.

12.2.1 Openings in floors, walls, and ceilings.

Openings around pipes or other structures that come through walls, floors and ceilings should be sealed. Caulk, foam, seal, paint, or otherwise fill any cracks and holes larger than the thickness of a credit card.

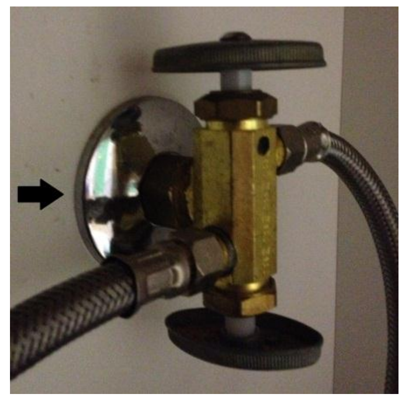
Effective on:	Bed Bugs, Ants, Cockroaches, and Misc. Insects.
Compatibility Issues with Other Design Goals:	Residential Code Table N1102.4.1.1 and International Energy Conservation Code R402.4.1.1 and C402.4.2 apply if gaps involve the building thermal envelope..
References:	Bay Area Local Initiatives Support Corporation, 2006, and Gangloff-Kaufmann and Pichler, 2008

Principle 13.1 Prevent moisture accumulation in bathrooms.

13.1.1 Floor, wall, and ceiling penetrations.

All penetrations of floors, walls, and ceilings should be sealed with metal escutcheon plates if feasible, or with polyurethane foam, silicone sealant, or other flexible sealant. Penetrations include electrical wires, supply and drain pipes, heating and ventilation systems, and recessed lights. Larger gaps may require the addition of copper or stainless steel wool to the foam, in order to effectively bar access to rodents.

Effective on:	Ants, Bed Bugs, Cockroaches, Spiders
Compatibility Issues with Other Design Goals:	Residential Code Table N1102.4.1.1, International Energy Conservation Code R402.4.1.1, and C402.4.2 apply if gaps involve the building thermal envelope
References:	Peterson, 2002



Source: Center for Environmental Health

13.1.2 One-piece countertops.

Countertops should be one piece if possible, that is, with an attached backsplash. If this is not feasible, use an elastomeric sealant to seal along edges of countertops and backsplashes where they meet walls.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Allen, 2009

13.1.3 One-piece tub or shower enclosures.

Use one-piece tub or shower enclosures where they are appropriate with the bathroom design, to minimize potential infiltration of moisture.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Peterson, 2002

13.1.4 Water controls.

In large shower enclosures, offset water controls so that they are close to the door. This makes them easier to use, and lessens the likelihood of water escaping the shower.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Peterson, 2002

13.1.5 Shower shelves and soap holders.

Slope horizontal surfaces of soap holders, shampoo cubbies, and shower seats so water drains into the shower or tub. This reduces moisture buildup.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Peterson, 2002

13.1.6 Toilet tanks.

Use insulated toilet tanks to minimize toilet sweating and moisture buildup.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost issues
References:	Peterson, 2002

13.1.7 Slope ventilation ducts.

Ensure horizontal ventilation ducts are sloped so that condensation water doesn't accumulate in the ducts.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Peterson, 2002

13.1.8 Bathroom fans with a humidistat.

Install bathroom fans with a humidistat to more effectively avoid moisture buildup. Humidistats automatically turn on fans when humidity reaches a certain level.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost issues
References:	Peterson, 2002

Principle 14.1 Design kitchens for easy cleanability and pest inspections.

14.1.1 Joints between toe-kicks and floor.

Use curved joints between floor and the vertical toe-kick under cabinets rather than right angle joints. "Roll" the edge of the floor up to the toe-kick with a smooth curve. Ensure that edges are properly sealed to avoid creating harborages for pests.

Effective on:	Ants, Cockroaches, Flies, Spiders, and Misc. Insects
Compatibility Issues with Other Design Goals:	None specified
References:	Better Homes and Gardens, 2012

14.1.2 Joints between sinks and countertops.

Avoid joints that are difficult to clean between sinks and countertops. Use undermount or integral sinks.

Effective on:	Ants, Cockroaches, Flies, Spiders, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Better Homes and Gardens, 2012

14.1.3 Kitchen cabinets with smooth, flat doors.

Specify cabinets with flat rather than raised panel doors. Raised panels or elaborate moldings create more opportunities for dirt accumulation. Enamel, gloss paint, or other smooth finishes are preferable to make cleaning easier.

Effective on:	Ants, Cockroaches, Misc. Insects
Compatibility Issues with Other Design Goals:	Aesthetic issues
References:	Better Homes and Gardens, 2012

Principle 14.2 Eliminate moisture buildup in kitchens.

14.2.1 One-piece countertops.

Use one piece countertops with attached backsplash when possible. If one-piece countertops are not feasible, use an elastomeric sealant to seal along edges of countertops and backsplashes where they meet walls.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Subterranean Termites, Misc. Wood Destroying Insects, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Allen, 2009

Principle 14.3 Eliminate potential pest harborage.

14.3.1 Cabinets contacting floor and walls.

Using an elastomeric sealant, seal joints where cabinets contact the floor and walls. The wall behind the cabinet should be free of holes or voids. The goal is to prevent access to hidden spaces favored by cockroaches. This is especially critical in institutional kitchens.

Effective on:	Ants, Cockroaches, Spiders, Misc. Insects
Compatibility Issues with Other Design Goals:	Sealing requires ongoing maintenance to ensure that the seal remains intact. Designer/project manager/contractor will need to verify the quality of sealing.
References:	Allen, 2009, and Technical Advisory Committee

Principle 15.1 Design kitchens for easy cleanability and pest inspections.

15.1.1 Food storage areas.

Food storage should be elevated off the floor and away from walls to facilitate inspection and cleaning.

Effective on:	Ants, Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee, and Marer, 1991, p.152

15.1.2 Coved junctions.

Wall-wall and wall-floor junctions should be coved to facilitate easier cleaning and prevent the accumulation of debris. Wall-ceiling junctions should be coved or sealed. Rubber or flexible plastic baseboard coving should be avoided, since it is very difficult to remove and inspect. Avoid cove base that is installed with adhesive. Choose coving that does not include an air gap under the curve, which could provide harborage for cockroaches.

Effective on:	Ants, Cockroaches, and Flies
Compatibility Issues with Other Design Goals:	Cost issues
References:	United Nations World Food Programme, 2009, and Technical Advisory Committee

15.1.3 Lighting in storage areas.

Storage areas should have adequate lighting to allow efficient cleaning and easy pest inspection.

Effective on:	Ants, Cockroaches, Flies, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	Energy issues, Cost issues
References:	Marer, 1991, p. 152

15.1.4 Access to suspended ceilings.

Provide access to voids above suspended ceilings for inspections and cleaning. In large buildings, provide walkways for this purpose.

Effective on:	Ants, Cockroaches, Flies, Spiders, Mice, and Rats
Compatibility Issues with Other Design Goals:	Cost issues
References:	United Nations World Food Programme, 2009

15.1.5 Cabinets with legs.

Specify cabinets with legs to facilitate cleaning underneath. Legs should either be bolted to the floor with gaskets or sealant to eliminate gaps, or should be on wheels to enable easy moving.

Effective on:	Ants, Cockroaches, Flies, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	None conflicted
References:	Technical Advisory Committee

Source: San Francisco Dept. of the Environment

15.1.6 Wheeled appliances.

Specify the use of wheeled stoves, mixers, refrigerators, and other appliances to encourage regular cleaning. Wheel fenders should include adequate clearance for cleaning around the wheels.

Effective on:	Ants, Cockroaches, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Allen, 2009, and Technical Advisory Committee

Source: San Francisco Dept. of the Environment

15.1.7 Drains.

Locate drains so that they are accessible for cleaning.

Effective on:	Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee

15.1.8 Flush thresholds in doorways.

When possible use flush thresholds in doorways. Thresholds collect dirt and food debris that can attract fruit flies or roaches.

Effective on:	Ants, Cockroaches, and Misc. Insects
Compatibility Issues with Other Design Goals:	Functional issues: Raised thresholds are sometimes necessary to connect different levels of flooring, or to ensure tight door fit.
References:	Technical Advisory Committee

15.1.9 Food preparation areas.

When possible, locate food preparation areas on islands rather than against walls. Cleanup is generally easier around islands.

Effective on:	Ants, Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	Functional issues. The layout of some kitchen areas and utilities may not permit the use of islands for food preparation.
References:	Technical Advisory Committee

15.1.10 Stainless steel backsplashes.

Install stainless steel backsplashes behind sinks and work surfaces for easier cleaning and avoid moisture buildup. Use sealant around edges.

Effective on:	Ants, Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005; Technical Advisory Committee

Principle 15.2 Eliminate moisture buildup in kitchens.

15.2.1 Ventilation in moist areas.

Provide extra ventilation for dishwasher, cooking line, and in the mop room. This can be accomplished through modifications of venting or through installation of small fans. Reduction of moisture buildup will inhibit fruit flies and other pests.

Effective on:	Ants, Cockroaches, Flies, and Misc. Insects
Compatibility Issues with Other Design Goals:	Cost issues and energy conservation issues. Installation of extra fans or modifying HVAC venting may result in higher energy use.
References:	Technical Advisory Committee

Principle 15.3 Minimize pest entrance into kitchen.

15.3.1 Separation of refuse disposal, recycling areas, and food delivery entrances.

Refuse disposal, recycling areas, and food delivery entrances should ideally be located away from frequently used entries. Refuse disposal and recycling areas attract flies and other pests, even when bins are well sealed and frequently cleaned. If the disposal area is adjacent to frequently used entries, such as those used for food deliveries, it is easier for the flies to enter the kitchen.

Effective on:	Ants, Cockroaches, Flies, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	Functional issues. Layout of building may not be flexible enough to permit use of this tactic. May require additional space.
References:	Technical Advisory Committee, and Ehmann, 1997

Source: San Francisco Dept. of the Environment

15.3.2 Self-closing doors for food storage rooms.

Use self-closing doors for food storage rooms to shut out rodents and some insect pests. Doors should be adequately sealed around the edges, with door sweeps or bottoms and no gaps over 1/4 inch.

Effective on:	Ants, Cockroaches, Flies, Mosquitoes, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	Cost issues,aesthetic issues
References:	Simmons, 2005, and United Nations World Food Programme, 2009

15.3.3 Wiring and pipe penetrations.

Seal all penetrations through walls and floors, including wiring and pipe penetrations through wall framing at top and bottom plates. Use either an elastomeric sealant or fire block, depending on the size of the gap, its location, and local building codes. This is especially important in institutional kitchens where there is no tolerance for pest infestations. For larger gaps, including copper or stainless steel wool with foam may be necessary to exclude rodents.

Effective on:	Ants, Cockroaches, Flies, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	Sealing gaps can increase energy efficiency as well as preventing pest movement
References:	Technical Advisory Committee

Principle 15.4 Eliminate potential pest harborage.

15.4.1 Wall hangings and signs.

Any wall storage, ornamentation, signage, bulletin boards, etc. should be sealed using elastomeric sealant or hung at least 1/4 inch from the wall to discourage pest harborage.

Effective on:	Ants, Cockroaches, Spiders, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee

15.4.2 Storage rooms without void spaces.

If rodent pressure is high, design food storage rooms without double walls, false ceilings, enclosed staircases, boxed plumbing, and voids under cabinets. This permits easy inspection and removes harborage.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues. Existing building design requirements may make it impossible to avoid all void spaces.
References:	Marer, 1991, p. 142

15.4.3 Ceramic outside corner tiles.

Avoid use of ceramic outside corner tiles. Ceramic tiles located in heavily used areas are highly prone to breakage. Broken tiles provide access to voids that can harbor pest insects. Durable outside corners, such as metal or plastic, are preferred alternatives.

Effective on:	Ants, Cockroaches, Flies, Spider, Misc. Insects.
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee

Source: photographer

Principle 16.1 Design and construct utility penetrations, such as water pipes, electrical wires and conduit, cold air return ducts on forced air furnaces, and exhaust vents, to minimize pest intrusions.

16.1.1 Rodent-resistant materials to seal around utility penetrations.

Use escutcheons, cement mortar, or copper mesh or hardware cloth embedded in patching plaster to seal any openings around utility penetrations.

Effective on:	Ants, Cockroaches, Flies, Mosquitoes, Wasps, Bees, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying Insects, Spiders, Misc. Insects, Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Hygnstrom et al.,1994, Witmer, 2008, and Corrigan, 2008b

Source: San Francisco Dept. of the Environment

16.1.2 Use sealant on small gaps around penetrations.

Where rodent pressure is not high, or with gaps < ¼", use silicone sealant to seal around utility penetrations to deter insect movement.

Effective on:	Ants, Cockroaches, Dampwood Termites, Formosan Termites, Subterranean Termites, Misc. Wood Destroying Insects, Spiders, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Environmental Protection Agency, 1997

16.1.3 Air intakes and vents.

Outside air intakes or vents for wall-mounted heaters, air conditioners, and exhaust fans should be screened to exclude insects a variety of pests. Use 10-mesh screen or smaller and design/install the screen so that it can be easily removed for cleaning.

Effective on:	Misc. Birds, Ants, Flies, Mosquitoes, Wasps, Bees, Drywood Termites, Misc. Wood Destroying, Spiders, Misc. Insects, Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Small mesh screen allows less air to flow through. HVAC calculations should take screen into account.
References:	Simmons, 2005

16.1.4 Outlets and switches.

Use foam gaskets behind electrical cover plates to seal off access to pests, particularly in pest sensitive areas such as institutional kitchens.

Effective on:	Ants, Cockroaches, Spiders, and Misc. Insects
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005; Technical Advisory Committee

Source: San Francisco Dept. of the Environment

16.1.5 Cleaning around utility penetrations.

There should be adequate space and access for cleaning around utility penetrations.

Effective on:	Ants, Cockroaches, Flies, Mice, and Rats
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005

16.1.6 Dryer exhaust vents.

Terminal ends for clothing dryer vents are available that exhaust the air vertically rather than horizontally and may be more effective in excluding rodents than the usual flapper-type vent ends.

Effective on:	Mice, Rats, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Hoddenbach et al., 1997

Principle 16.2 Design trash and laundry shafts to exclude pests and minimize pest harborage.

16.2.1 Chute doors.

Trash and laundry chutes should have tight-fitting doors. Avoid any gaps between door and surrounding wall.

Effective on:	Ants, Cockroaches, Flies, Wasps, Bees, Spiders, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	None identified
References:	Northeastern IPM Center, 2012

16.2.2 Chutes circular in cross section.

Use metal garbage and laundry chutes with a circular cross section to avoid accumulation of debris in hard-to-clean corners.

Effective on:	Ants, Bed Bugs, Cockroaches, Flies, Spiders, Misc. Insects, Mice, and Rats
Compatibility Issues with Other Design Goals:	Cost issues for retrofits
References:	McKuen, 2010

16.2.3 Trash chute size.

Hopper doors into vertical trash chutes should be large enough to fit a full trash bag, to avoid the accumulation of debris from torn bags and keep chutes cleaner.

Effective on:	Ants, Cockroaches, Mice, Rats, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Northeastern IPM Center, 2012

Principle 17.1 Exclude rodents from refuse and recycling areas.

17.1.1 Prevent access to refuse and recycling areas.

Design refuse and recycling areas with concrete pads that extend past the boundaries of the enclosure so that rodents cannot burrow into the enclosed area.

Effective on:	Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues
References:	Simmons, 2005, and Technical Advisory Committee

17.1.2 Rodent-resistant enclosures.

Enclose refuse and recycling areas with metal, concrete, or similar materials to prevent vertebrates from gnawing or climbing the enclosure. Enclosures should be solid and extend all the way to the ground. Do not plant ivy around enclosures.

Effective on:	Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues
References:	Simmons, 2005, and Technical Advisory Committee

17.1.3 Pest-resistant containers

Use refuse containers that are heavy duty, rust resistant, rat and damage resistant, and equipped with tight-fitting lids. Racks or stands prevent corrosion or rusting of containers, reduce rat shelter under containers, and minimize the chance of containers being overturned.

Effective on:	Pigeons, Misc. Birds, Flies, Wasps, Bees, Misc. Insects, Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Hygnstrom et al., 1994

Principle 17.2 Design refuse and recycling areas for easy cleaning.

17.2.1 Floors areas.

Use concrete floors in refuse and recycling areas.

Effective on:	Pigeons, Misc. Birds, Cockroaches, Flies, Spiders, Misc. Insects, Mice, Rats, Opossums, Raccoons, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues
References:	Dublin Municipal Code, 2012

17.2.2 Drainage.

Slope floor of recycling and refuse area to a drain connected to the sanitary sewer.

Effective on:	Pigeons, Misc. Birds, Cockroaches, Flies, Spiders, Misc. Insects, Mice, Rats, Opossums, Raccoons, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Cost issues
References:	Dublin Municipal Code, 2012

17.2.3 Hose bib.

Provide a hose bib near the enclosure for periodic cleaning.

Effective on:	Pigeons, Misc. Birds, Ants, Cockroaches, Flies, Spiders, Misc. Insects, Mice, Rats, Opossums, Raccoons, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	Infrastructure issues, if plumbing is not located nearby
References:	Dublin Municipal Code, 2012

Principle 18.1 Durable pest-resistant construction materials.

18.1.1 Termite resistant building materials.

Termite-resistant materials include brick, concrete, stone, naturally resistant wood, metal, and rigid plastics. Naturally resistant woods commonly used in North America include: western red cedar, redwood, incense cedar, Port Orford cedar, black locust, northern white cedar, and Alaska cedar are known to dissuade termite infestations . Using these durable woods makes infestation less likely but does not guarantee that infestations will not occur. It is also important to note that only the heartwood from these species is resistant.

While they do not constitute a food source for wood-destroying insects, brick, concrete block, and plastic may still provide harborage for the pests. Foam insulation mounted on the outside of foundations, for example, provides near-ideal temperature and humidity conditions for termite tunnels. Regular termite inspections are important even when using resistant materials.

Effective on:	Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, and Misc. Wood Destroying Insects
Compatibility Issues with Other Design Goals:	Cost and aesthetic issues
References:	Standards Australia International Ltd., 2000; Scheffer and Morrell, 1998; and University of Hawaii Termite Project, 2006

18.1.2 Rodent resistant building materials.

Rodent teeth are well adapted to gnawing through all but the hardest materials. Rats have been known to gnaw through lead. Rodent-resistant materials include concrete with a minimum thickness of 2 inches (5.1 cm) if reinforced, or 3.75 inches (9.5 cm) if not reinforced; galvanized sheet metal if 24 gauge or heavier for wall or pipe barriers, 22-gauge or heavier for kick plates or door edging, or 14-gauge if perforated or expanded sheet metal grills; brick if 3.75 inches (9.5 cm) thick with joints filled with mortar; hardware cloth (wire mesh) if woven, 19-gauge, 1/2- x 1/2-inch (1.3- x 1.3-cm) mesh to exclude rats or 24-gauge, 1/4- x 1/4-inch (0.6- x 0.6-cm) mesh to exclude mice; aluminum if 22-gauge for frames and flashing or 18-gauge for kick plates and guards; plaster; or corrugated metal.

Effective on:	Mice, Rats, Opossums, Raccoons, and Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Hygnstrom et al., 1994

Principle 18.2 Design for easy inspection.

18.2.1 Minimize inaccessible spaces.

Example of inaccessible spaces include: false ceilings, false bottoms under cabinets, pegboard storage systems, air plenums, gaps behind or within machinery, spaces behind coved baseboards, or enclosed spaces under bathtubs.

Effective on:	Misc. Birds, Ants, Bed Bugs, Cockroaches, Fleas, Flies, Mosquitoes, Wasps, Bees, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying, Spiders, Misc. Insects, Mice, Rats, Opossums, Raccoons, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Simmons, 2005, and Technical Advisory Committee

18.2.2 Access to enclosed spaces.

Where hard-to-access spaces are necessary, provide enough access to allow inspections of the space. Examples include: 1) Provide hatches or walkways for inspection of voids above suspended ceilings, 2) leave 6 inch clearance between wood structures and soil (preferably 18 inches in areas with high termite pressure), and 3) make sure expansion joints or utility breaks in foundation are accessible to inspection. Note that access to attics, crawl spaces, and other underfloor spaces is required by code.

Effective on:	Pigeons, Misc. Birds, Ants, Bed Bugs, Cockroaches, Fleas, Flies, Mosquitoes, Wasps, Bees, Dampwood Termites, Formosan Termites, Drywood Termites, Subterranean Termites, Misc. Wood Destroying, Spiders, Misc. Insects, Mice, Rats, Opossums, Raccoons, Misc. Vertebrates
Compatibility Issues with Other Design Goals:	None identified
References:	Technical Advisory Committee, and International Building Code 1209 and International Residential Code R408.4 (2012)

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