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Construction Practices: The Good, the Bad, and the Ugly

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Over the last two decades, numerous field and laboratory studies have tested the best techniques for preventing erosion and trapping suspended sediment at construction sites. The U.S. EPA has incorporated many of these findings into its guidance documents for the NPDES stormwater and nonpoint source control programs (U.S. EPA, 1992; 1993). However, very few of the studies have assessed how well these plans are actually implemented at construction sites.

Anecdotal evidence suggests that poor installation and maintenance of construction practices is endemic in many state and local erosion and sediment control (ESC) programs (Banach, 1988; Dawson, 1988; Doenges *et al.*, 1990; Lemonde, 1988). Detailed information, however, is lacking on the specific problems encountered during implementation (Dawson, 1988; Doenges *et al.*, 1990). Systematic analysis of ESC program implementation is needed to advance these practices. Designers need to know which construction practices are most problematic and know how to limit performance failures through better design and inspection.

Sediment control inspectors can also benefit from this kind of information. For example, many inspectors learn job skills through an apprenticeship process which unfortunately relegates much learning to trial and error despite the best efforts of senior ESC professionals to help them "learn the ropes." In other cases, problems are encountered on such a piecemeal basis that trends cannot be easily discerned.

This article sheds light on implementation problems that persist among many commonly prescribed construction practices based on a comprehensive evaluation of North Carolina's ESC Program undertaken in 1990. Problems with construction practices were identified through both expert opinion surveys and an investigation of over 1,000 prescribed construction practices in the field. Expert opinions were obtained through a mail survey of 44 North Carolina ESC administrators using the Total Survey Design method. Responses were received from 77% of the total population.

Expert opinion was sought on two key implementation issues. First, administrators were asked to rate a list of commonly used construction practices on a subjective five-point effectiveness scale (excellent, good, average, fair, and poor) based on their typical field experiences. Second, the administrators were also asked to comment on their perception of the main cause(s) of failures for each construction practice. Possible reasons for failures included that the practice was installed poorly, did not work, or was poorly maintained.

The field investigation provided an independent assessment of ESC implementation for more than 1,000 construction practices evaluated in a total of 128 ESC plans within nine North Carolina jurisdictions. The nine jurisdictions were selected to adequately represent construction sites in each of North Carolina's three physiographic regions (mountain, piedmont and coastal plain) and across three different levels of program administration (i.e., municipal, county and state administered programs).

Project sites were randomly selected from a list of active construction projects within each jurisdiction using a random assignment procedure. The selection procedure provided a fairly even mix of development types: 56% of the construction projects were residential and 44% were non-residential. The quality of ESC implementation was evaluated in terms of (a) whether the practices had been adequately installed and (b) if they were adequately maintained.

Study Results

Expert Opinion on ESC Practice Performance

Few North Carolina ESC administrators were satisfied with the typical field performance of most construction practices; only three out of the 11 construction practices were considered to be good or excellent (Figure 1). Sediment basins, sediment traps, and riprap stabilized channels received the highest percentage of favorable ratings. The worst performers, by a large margin, were brush barriers and straw bales. Only two out of 34 administrators rated typical field performance as "good" and none viewed typical brush barrier performance as satisfactory. Evaluations also tended to be negative on pre-fabricated silt fence and filter strip performance. Opinion was more varied on the adequacy of vegetatively stabilized channels, slope drains, constructed silt fence, and storm drain inlet protection (SDIP) measures.

A majority of the experts attributed construction practice failure to poor installation (Table 1). Most administrators identified poor installation as the primary cause of failure for filter strips, pre-fabricated silt

fence, constructed silt fence, slope drains, vegetatively stabilized channels, and riprap lined channel. In many cases, however, poor maintenance ran a close second as the primary cause of likely failure. Most administrators identified poor maintenance as the principal cause of failures for sediment basins, sediment traps, and storm drain inlet protection measures.

Again, the most technically questionable construction practices were thought to be brush barriers and straw bales. Table 2 summarizes typical comments from administrators from the open response option on the survey.

Field Survey Performance Ratings

The field survey corroborated much of the expert opinion. For example, it appears that few plan reviewers are allowing the use of questionable practices. For example, only two of the 128 sediment control plans evaluated prescribed the use of straw bale or brush barriers. Likewise, pre-fabricated silt fence, filter strips, and slope drains were used sparingly.

Perhaps the most interesting finding was the number of construction practices that were never installed

Table 1: Main Reason for Construction Practice Failure as Identified by North Carolina Administrators (reported in percentage response), N = 22-29

Erosion and sediment control measure	Technically deficient (%)	Poor installation (%)	Poor maintenance (%)
Brush barriers	58	29	13
Straw bales	64	20	16
Filter strip	23	41	36
Pre-fabricated silt fence	23	54	23
Silt fence	7	57	36
Sediment trap	0	38	62
Sediment basin	11	29	60
Inlet protection	16	40	44
Slope drain	0	76	24
Vegetated channel	27	57	15
Riprap channel	15	74	11

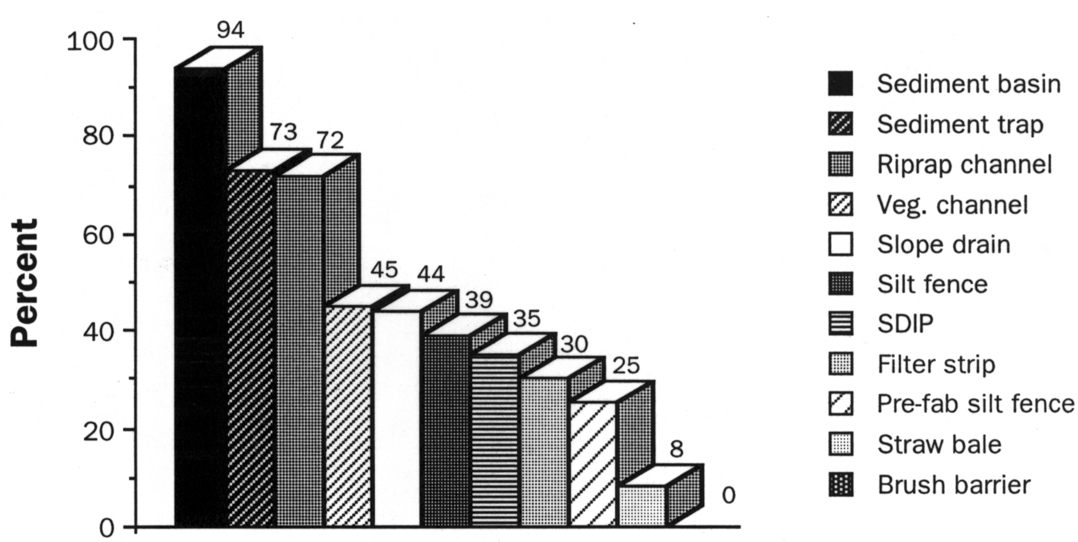

Figure 1: Administrators' Performance Ratings—Percent Indicating Satisfactory Performance

even though they were shown on the plan. More than a quarter of the two most commonly prescribed construction practices (storm drain inlet protection and silt fence) were never installed and nearly half of all prescribed velocity dissipators were not in place.

The two most favored practices, SDIP and silt fences, were frequently installed in a poor manner. Among those SDIP measures actually installed, about a third were not properly constructed (construction lacked required materials like reinforcing wire and adequate coverage of the base with filtration material); 29% were not properly anchored (primarily silt fence designs); and nearly half needed additional maintenance if they were to perform properly (problems included torn filter fabric, damage from vehicular impact and sediment build-up). Because of those failures, evaluators noted visible sediment entering into drainage systems in about one out of every five storm drain inlet protection measures installed.

More than 40% of silt fence applications were poorly installed and two-thirds required maintenance to perform properly. The most common installation problems included failure to use reinforcing wire (42%), failure to anchor filter fabric (33%), and failure to appropriately space posts or install the full length of required fencing (22%). The most common maintenance problems were failure to repair damaged fencing (whether knocked down by construction vehicles, hydraulic overload, or silt build-up) and damaged filter fabric (also possibly due to construction activities or natural deterioration).

The final column in Table 3 corroborates much of the anecdotal evidence that poor maintenance remains a persistent impediment to effective sediment control. With only three exceptions, more than one out of every four ESC practices were considered to be functionally impaired because of poor maintenance. Once again, the two most commonly used construction practices were among the top five offenders. And, while most sediment basins and traps were installed correctly, nearly one-half of the traps and one-fourth of the basins were reported to fail because of poor maintenance.

Finally, the field survey examined several construction practices that were not evaluated in the expert opinion surveys, including anti-tracking pads, filter berms and dikes. For example, while anti-tracking pads are widely recognized as an important part of erosion control plans, almost half of the plans failed to require them (and of those installed, almost a third needed maintenance). Second, the field survey revealed that silt fence has generally replaced earthen dikes as the diversion measure of choice at most construction sites. The widespread use of silt fence perhaps should be re-evaluated in light of their dismal performance in the field, compared to surprisingly strong performance of dikes.

Table 2: Comments on Why Construction Practices Fail

Stormwater Management Practice	Comments
Straw bales and brush barriers	Rapid loss of filtration capacity due to deterioration and gaps often left between measure and ground.
SDIP and silt fence	Failure to install all parts of the measure (e.g., reinforcing wire), failure to anchor the base, failure to cover entire designated area with fence, and construction vehicles back over devices.
Filter strips	Undersized filter area, sparse vegetation, and concentrated runoff at entry.
Vegetative and riprap channels	Inadequate channel bed construction and attempted vegetative stabilization in high velocity flow.
Slope drains	Failure to anchor drain to slope, failure to make inlet water tight, failure to install velocity dissipater at outlet, and failure to leave inlet clear of debris and sediment build up.
Sediment basins and traps	Failure to remove built up sediment, failure to stabilize embankments, spillway deterioration, improper levelling of embankments, failure to anchor riser pipe, failure to install trash rack.

The Good, the Bad, and the Ugly

What lessons can be drawn from the above analysis? Well the good news, at least in North Carolina, is that plan reviewers and inspectors are reducing field performance problems by minimizing the use of construction practices with a chronic history of poor implementation (i.e., the low use of straw bales, brush barriers, pre-fabricated silt fence, and filter strips). The bad news is that the study has corroborated prior anecdotal evidence that poor implementation remains a widespread obstacle to effective sediment pollution control. The worst news is that these results came from an investigation of a program that many consider to be one of the strongest ESC programs in the nation. This suggests that ESC programs may perform even worse in states that rely solely on voluntary compliance.

The study raised many more questions than it answered. For example, it provided little insight regarding underlying causes of the installation and maintenance failures noted. Certainly one could take the easy route and blame all implementation problems on developers and their grading contractors since they are arguably responsible for ensuring that construction practices outlined in their sediment control plans are

Erosion and sediment control measures	No. construction practices required in plan	Percent actually installed	Percent installed correctly	Percent adequately maintained
Storm drain inlet protection	189	71 *	72 *	55 *
Silt fence	174	67 *	58 *	34 *
Sediment trap	155	86	86	58 *
Veg./earth channel	147	77	98	87
Velocity dissipaters	147	51 *	86	69 *
Anti-tracking pad	66	89	89	67 *
Sediment basin	43	84	94	75 *
Filter berm	25	52 *	85	54 *
Earthen dike	25	92	100	92
Riprap channel	20	50 *	90	50 *
Check dam	20	80	94	63 *
Pipe slope drain	9 **	89	100	50
Filter strip	4 **	100	100	100
Straw bale	2 **	100	50	0
Brush barrier	1 **	100	0	0
Prefab silt fence	1 **	100	100	100

Table 3: North Carolina Field Survey of the Performance of Construction Practices

* 25% or more of practices rated inadequate for listed criterion
** Inadequate number of cases for analysis

installed correctly. However, such an antagonistic approach undoubtedly over simplifies what in many cases is likely to be a complex situation.

Consider, for example, the silt fence installation and maintenance problems identified by the field survey. The cynic might conclude that the problem is simply one of developers saving a buck. And, while some installation problems are surely due to this motive, a lack of training may also be responsible. In several instances, it was clear that the grading contractor had incurred all material and labor installation costs, but the construction crew lacked the proper training to properly anchor the fence. In other instances, contractors constructed the silt fencing to plan specifications, but placed them in locations where they served little practical purpose. This problem often occurred when erosion control plans contained vague field information, such as notes that merely specify "Silt fence to be placed where necessary."

Likewise, while many maintenance problems are the result of neglect, in many other instances, problems result from design problems such as hydraulic overload or inappropriate fence placement (e.g., where vehicles are likely to damage the devices or leave inadequate room for maintenance). The point of this discussion is not to shift blame, but rather to emphasize that installation and maintenance problems often may be more complex than they initially appear. Implementation problems may stem not only from a lack of commitment, but also from a lack of knowledge on *how* to comply (e.g., poor training, poor plans, and site-specific constraints).

Given the critical importance of field implementation of ESC programs and the apparent shortcomings that exist, much more attention should be focused on improving plan implementation. The task for researchers and environmental professionals alike is to identify the principal causes of construction practice failures and

test corrective design, technical assistance, and enforcement responses so that a better foundation for effective program implementation can be undertaken.

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